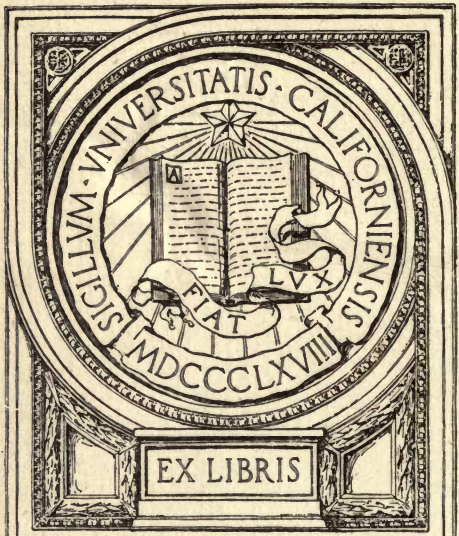

A HANDY-BOOK

OF

ROCK NAMES,

WITH

BRIEF DESCRIPTIONS OF THE ROCKS.

BY

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PREFACE.

A WANT expressed by many Geologists and often felt by the Author, is a classified HANDY-BOOK OF ROCK NAMES. It is hoped that, until a better appears, this Manual may be useful to the Public.

To write such a work satisfactorily is no easy task. In other branches of Natural Science, such as Botany, Zoology, and the like, some systematic nomenclature has been followed, but in Geology no one system has been used, or all system has been ignored. It is not uncommon to find eminent Petrologists calling the same rock by several names, or, what is more perplexing, using for a rock a name already given to a totally different one. At the present time Rock names are in such confusion that if an observer names a rock, without at the same time mentioning his authority, he may be supposed to be referring to a rock, or even rocks, totally different to that which he intended to illustrate. This irregularity has caused many names to be used, not only unscientifically but also absurdly, as the original name may refer to a mineral or character not possessed by the rock or rocks to which it is now applied. From the above it is evident that a compiler of such a book as this Manual must run contrary to the opinions and

prejudices of many geologists; therefore some will find fault even if the work could be well done.

I would wish to impress on my readers that this book has been written as a reference for surveyors and students while engaged in the field. Should they desire a perfect knowledge of rocks, they must study the various papers and works of the different eminent Petrologists. The work, necessarily, is far from perfect: still I hope it may be of some small use or help to learners of Geology.

During the compilation of this Manual, the writings of numerous Petrologists have been consulted and quoted; also works on general subjects from which information could be procured. Dana's suggestions as to the termination of Rock names have been adopted as far as practicable, while the older names for rocks are generally adopted, except when they are objectionable or better names have since been proposed. Such local names as were known are also given, as they may assist explorers in gleaning information about a country. To various fellow-labourers I am much indebted: to D. Forbes, F.R.S., &c., for information; also to W. King, Dep. Supt. Geol. Surv., India, and for his valuable assistance while arranging and classifying the rocks. I should also mention the names of the Rev. M. H. Close, M.R.I.A., &c.; Stackpoole Westropp, M.D., M.R.I.A., &c.; and H. Leonard, M.R.I.A.; besides others who have supplied me with lists of local names.

G. H. K.

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HANDY-BOOK OF ROCK NAMES.

INTRODUCTORY REMARKS.

THE term Rock, in a geological sense, includes every solid substance that is an ingredient, or forms part, of the earth. Thus loose sand, clay, peat, and even vegetable mould, geologically speaking, are rocks. Jukes thus defines a rock:—"A mass of mineral matter consisting of many individual particles, either of one species of mineral, or of two or more species of minerals, or of fragments of such particles. These particles need not at all resemble each other in size, form, or composition; while, neither in its minute particles, nor in the external shape of the mass, need a rock have any regular symmetry of form." Rocks are most variable in condition and structure; soft or hard, loose or compact, friable or tenacious, coarse or fine, crystalline or homogeneous; or they may be scoriaceous, vesicular, hyaline, &c. &c.

Rocks may be chemically, mechanically, or organically formed, or two or more of these combined; they may be stratified or unstratified, igneous or aqueous, or partaking of the nature of both. Various classifications have been adopted by different writers on the subject, each taking dif-

ferent peculiarities as a foundation for his system. Jukes and others have divided rocks into four classes; namely, Igneous, Aqueous, Aerial, and Metamorphic; while Forbes, who wrote subsequently, has simplified this division, and makes two great classes of all rocks.

Forbes calls his first class by the names INGENITE or SUBNATE ROCKS; *i.e.*, "such as are born, bred, or created within or below;" and the second he calls DERIVATE ROCKS, "since directly or indirectly they are all derived from the destruction of the former."

Under Ingenite rocks are included all the true igneous, intrusive or irruptive rocks, whether they are still in their original state, or whether they have been subsequently affected by metamorphic action, as also the metamorphosed sedimentary rocks; since all these have been bred or formed within or below the surface of the earth. Thus all granites, whether truly igneous or metamorphic,* are included. The Derivate order consists chiefly of sedimentary rocks, but it will include some, such as DOLOMYTE,† HALYTE, &c., which some authorities refuse to regard as sedimentary rocks.

In this Manual these suggestions will be followed, and the rocks classed in two orders; namely,

* Some authorities deny that any granite can be of metamorphic origin. To me, however, there does not appear to be any room for doubt, for in different places I have found granite graduating through gneiss and schist into unaltered rocks.

† Dana suggests that all rock names ending in *ite* should be changed into *yte*, and the first termination should be kept solely for minerals. A general adoption of this suggestion would prevent the confusion that at present exists when so many rock masses and minerals have similar names,—such as AUGITE, STEATITE, &c. &c. Dana's names for the minerals are those that will be used in this Manual.

Order I., INGENITE ROCKS; and Order II., DERIVATE ROCKS.*

The first Order (INGENITE ROCKS) can conveniently be divided into four classes; namely, I. GRANITIC, II. PLUTONIC, III. VOLCANIC, and IV. TRANSITION, or METAMORPHIC SEDIMENTARY ROCKS.† These classes, however, necessarily merge into one another. GRANITE may be a true intrusive rock, or may have been formed *in situ* [*i.e.* where it is now found] by extreme metamorphic action. Granite is supposed to have been formed under great pressure, at a considerable depth beneath the surface of the earth; consequently it is never accompanied by tuff. Of it Jukes says:—"As the granite rocks are all hypogenous, or nether-formed—that is, have all been consolidated before reaching the surface of the earth, they are necessarily devoid of 'ash,' [tuff,] or of any mechanically derived accompaniment whatever."

Usually the sedimentary rocks associated with granite are more or less metamorphosed: sometimes the metamorphism is very slight indeed. This may be due to the granite having been formed at a lower zone or depth, and intruded into its present place in a semi-liquid state, under such low pressure that its heat, latent or otherwise, was unable to affect the associated rocks; or it may be

* Sterry Hunt and others have called the Derivate rocks by the name of INDIGENOUS ROCKS, and the Granitic and Igneous rocks, EXOTIC ROCKS. This classification, however, does not appear to include the metamorphic rocks, as they are in part indigenous, and in part exotic.

† Some of the metamorphic rocks were originally sedimentary, while others evidently were igneous. In this Manual it has been considered expedient to describe the latter with the groups to which they originally belonged.

due to those rocks being composed of a (suppose siliceous) material not easily affected by metamorphic action.

Allied with the granites are granitic rocks, in which a considerable portion of the quartz crystallized out prior to the other constituents. This, according to Scheerer and others, debars them from being classed as true granites. Nevertheless, this definition is controverted by Forbes and others, who contend that in some true granites a portion of the quartz crystallized out previous to the other constituents. These granitic rocks or ELVANYTES (*Quartz-porphyries*) are allied to the granite, being mineralogically similar, and always destitute of tuffs: they never occur contemporaneous or interstratified with the sedimentary rocks, but rather in irruptive masses or dykes; moreover, in places they merge into granite. On the other hand, it is not unusual at the margin of a mass of Elvanyte, or in dykes branching from a mass, to find Elvanyte changing into a rock identical with a Felstone. From these facts it would appear that Elvanyte is a connecting link between Granite and the Plutonic rocks. There is also another somewhat similar link; namely, the metamorphosed Plutonic rocks, as they merge into Granite.

The rocks here called PLUTONIC rocks can be divided into two groups; namely, FELSTONES, or highly siliceous rocks, and WHINSTONES, or basic rocks. Some of the rocks placed in the first of these groups are however a connecting link between the two, partaking of the nature of both, and merging on the one hand into Felstone, and on the other into Whinstone. These basic felstones are the HYBRID ROCKS of Durocher, and they include all the rocks originally called EURYTES by

Daubuisson [from *eureo*, to flow well or easily], on account of their fusibility. Felstones proper contain over 68 per cent. of silica; Durocher's Hybrid rocks between 65 and 55 per cent.; while the Whinstones contain a large percentage of pyroxene or amphibole, or such minerals.

Any of the Plutonic rocks may be contemporaneous, *i.e.* interstratified with the sedimentary rocks. Under such circumstances they are often associated with beds of tuff. Tuff also on some occasions occurs in dykes and pipes, when, apparently, it is the remains of old vents or funnels of eruption.

The VOLCANIC rocks appear capable of a division similar to the Plutonic rocks; the highly siliceous or the TRACHYTES, and the basic, or the AUGYTES. In them are also hybrid rocks, for which Scrope has proposed the name of GREYSTONE, and Abich that of TRACHYDOLERYTE. Volcanic rocks generally are accompanied by tuffs; of which more hereafter.

The METAMORPHIC SEDIMENTARY ROCKS may be placed here. They belong, indeed, also to the Derivate Order; but, being compelled to make a selection, we place them under the Ingenite, as this arrangement seems to involve the least inconvenience. They are Ingenite Rocks, as they have been in a certain sense *formed below*, yet their materials were previously derived from the destruction of other rocks, which gives them their relation to the second Order. They are capable of a nearly inexhaustible subdivision, not only on account of the different degrees of metamorphism to which they have been subjected, but also on account of the numerous and variable constituents entering into them.

Allied to the metamorphic rocks are such deri-

vate rocks as Dolomyte, Ophyte, Steatyte, &c., in which a secondary or pseudomorphic action has taken place—new minerals replacing the old constituents, and thereby changing the nature of the rock.

The second Order (DERIVATE ROCKS) may be divided into two classes; namely, I. SUBAQUEOUS, II. SUBAERIAL, which need not be dwelt upon now.

This Manual is divided into three parts. Part I. is a classified table of the rocks; Part II. is a description of the Ingenite rocks; and Part III. is a description of the Derivate rocks: while in the Index will be found an alphabetically arranged list of local, duplicate, and other rock names that do not appear *in the classified table of the rocks.* As before stated, Dana's termination of *yte* for rock names, on account of its convenience in distinction, is adopted; but at the same time the names ending in *ite* are also given for such as prefer them. The termination *oid* is only used to signify like, as *Granitoid,* granite-like; *ous* means a constituent that gives a character to the rock, as *Pyritous granite,* granite containing pyrite; while the termination *ic* points to quantity, as *felsitic,* containing a quantity of felsite (orthoclase intimately combined with quartz.—*See* quotation from Cotta, page 46).

In Parts II. and III. a general description of each class is given, and a general description of each group; while under each group will be found the subgroups, and under the latter the varieties, and, when necessary, the subvarieties. In these two parts names of classes are printed in large capitals, of groups in egyptian type, of subgroups and particular varieties in small capitals; while the

others, subvarieties and local names, are in italics. Synonymous names for groups, subgroups, and varieties are given when not highly objectionable, but the name that is considered most applicable appears first. Objectionable names, if mentioned, are printed in italics, and the objection to them pointed out.

All the groups are arranged under roman capitals; the subgroups under italic capitals; the varieties under small italic, and the subvarieties under small roman letters.

A student wishing to learn the description of a rock, must first look for the name in the Index, and if the name does not occur there, it will be found in the classified list in its proper group, class, and order; he must then refer for the description to either Parts II. or III.

NOTE.—While this Manual was in the press, Professor Joseph Le Conte's excellent paper on the "Features of the Earth's Surface" was published in "The American Journal of Science and Art," third series, vol. iv. As in it the formation of metamorphic granite is explained (p. 468), the student may be referred to it.

PART I.

CLASSIFIED TABLE OF THE ROCKS.

Order No. I.—*INGENITE ROCKS.*

(*Divided into Classes, Groups, Subgroups, and Varieties.*)

Class I.—GRANITIC ROCKS.

Group A.—Intrusive Granite (Highly siliceous granite).

Subgroup *A*. Pyritous intrusive granite.
Var. *a*. Beresyte.
B. Albitic granite.
C. Schorlaceous granite.
D. Granityte.
E. Felsitic granite.
F. Greissen, or quartzitic granite.
G. Porphyritic intrusive granite.
H. Pegmatyte.
Var. *a*. Graphic granite.
b. Blumen granite.
c. Plumose granite.

Group B. — Granite for the most part non-intrusive (Basic or oligoclase granite).

Subgroup *A*. Hornblendic granite.
Var. *a*. Titanitic granite.
b. Chloritic granite.
c. Talcose granite.
d. Epidotic granite.
B. Graphitic granite.
C. Hematitic granite.
D. Pyritous oligoclase granite.
E. Porphyritic oligoclase granite.
F. Gneissoid granite.

Var. *a*. Nodular granite.
b. Lenticular granite.

Subgroup *G*. Intrusive oligoclase granite.
H. Granitic felstone.

Group C.—Protogene.

Group D.—Elvanyte, or Quartz Porphyry.

Subgroup *A*. Felsitic and felspathic elvanyte.
Var. *a*. Orthoclasic elvanyte.
b. Oligoclasic elvanyte.
c. Rappakivi elvanyte.

B. Quartzitic elvanyte.
C. Micaceous elvanyte.
D. Pyritous elvanyte.
E. Hornblendic elvanyte.
Var. *a*. Micaceous hornblendic elvanyte.
b. Chloritic.
c. Felspathic.
d. Pyritous.

F. Chloritic elvanyte.
G. Granular elvanyte.
H. Compact elvanyte.
I. Gneissoid elvanyte.
J. Granitoid elvanyte.
K. Pyromeride.

Class II.—PLUTONIC ROCKS.

Group E.—Felstone, or Felsyte.

Subgroup *A*. Petrosilex.
Var. *a*. Felstone glass.
b. Ribaned petrosilex.

B. Quartzitic felstone.
Var. *a*. Oligoclasic quartzitic felstone.
b. Micaceous.
c. Hornblendic.
d. Chloritic.
e. Pyritous.
f. Striped.
g. Variolitic.

Subgroup *C.* Minette.
Var. *a.* Fraidronyte.
D. Euryte.
Var. *a.* Orthoclasic euryte.
b. Oligoclasic.
c. Micaceous.
d. Hornblendic.
e. Chloritic.
f. Quartzose.
g. Euryte porphyry.
h. Amygdaloidal euryte.
i. Vesicular.
j. Compact.
k. Slab.
l. Cleaved.
E. Compact felstone.
F. Granular felstone.
G. Friable felstone.
H. Rubbly felstone.
I. Cleaved felstone.
J. Foliated felstone.
K. Granulyte.
L. Felstone porphyry.
Var. *a.* Amygdaloidal felstone.
b. Vesicular felstone.
M. Gneissyte.
Var. *a.* Quartzose gneissyte.
b. Felsitic.
c. Micaceous.
d. Hornblendic.
e. Syenyte gneissyte.
f. Chloritic.
g. Talcose.
h. Porphyritic.
i. Schistoid.
N. Schistoid felstone.

Group F.—WHINSTONE.
Subgroup *A.* Doleryte.
Var. *a.* White rock.
b. Aphanyte-doleryte.
B. Melaphyre.
Var. *a.* Eukryte.
b. Magnetic melaphyre.

Var. *c.* Micaceous.
d. Porphyritic.
e. Amygdaloidal.
f. Vesicular.
g. Variolitic.

Subgroup *C.* Pyroxenyte.
D. Diabase.
Var. *a.* Pyroxenic diabase.
b. Uralitic.
c. Labradoritic.
d. Oligoclasic.
e. Magnetic.
f. Kersantyte.
g. Calcareous diabase.
h. Porphyritic.
i. Amygdaloidal.
j. Vesicular.
k. Variolitic.
l. Aphanyte-diabase.
E. Gabbro.
Var. *a.* Euphotide.
b. Noryte.
c. Hyperyte.
F. Dioryte.
Var. *a.* Amphibolyte.
b. Aphanyte-dioryte.
c. Kersanton.
d. Napoleonyte.
G. Syenyte.
Var. *a.* Quartzose syenyte.
b. Titanitic.
H. Hornblende rock.
Var. *a.* Actinolite rock.
b. Tremolite rock.
c. Hyperyte.
d. Dioryte.
e. Syenyte.
é. Felso-syenyte.
f. Mico-hornblende rock.

Group G.—Rocks due to Pseudomorphic Action or Weathering (Ingenite in part, derivate in part).

Subgroup *A.* Ophyte.
Var. *a.* Ophihornblende rock.
B. Steatyte.

Var. *a.* Felspathic steatyte.
b. Pyroxenic.
c. Amphibolic.

Subgroup *C.* Eklogyte.
D. Epidosyte.
E. Kaolin.
F. Fuller's earth.
G. Meerschaum.
H. Magnesyte.

Group H.—TUFF (Ingenite in part, derivate in part).

Subgroup *A.* Felstone tuff.
Var. *a.* Quartzose.
b. Calcareous.
c. Pyritous.
d. Cupriferous.
e. Hematitic.

B. Whinstone, or Basic tuff.
Var. *a.* Hornblendic.
b. Pyroxenic.
c. Chloritic.
d. Calcareous.
e. Pyritous.
f. Cupriferous.
g. Hematitic.

C. Calcareous tuff.
D. Arenaceous.
E. Argillous.
F. Hematitic.
G. Pyritous.
H. Cupriferous.
I. Steatitic.
J. Porphyritic.
K. Nodular.
Var. *a.* Concretionary tuff.
b. Spheroidal.

L. Shaly tuff.
Var. *a.* Flaggy.
b. Slaty.

M. Conglomeritic tuff.
Var. *a.* Brecciated tuff.
b. Plutonic agglomerate.

Class III.—VOLCANIC ROCKS.

Group I.—Trachytic Group.

Subgroup *A*. Rhyolyte.
Var. *a*. Liparyte.
b. Perlyte.
c. Obsidian.
d. Pumice.
e. Phonolyte.

B. Trachyte.
Var. *a*. Sanidine trachyte.
b. Drachenfels trachyte.
c. Domyte.
d. Andesyte.
e. Trachydoleryte.
f. Granular trachyte.
g. Compact trachyte.
h. Trachyte porphyry.
i. Trachyte lava.
j. Alumstone.

Group J.—Augitic Group.

Subgroup *A*. Augyte, or Doleryte.
Var. *a*. Nephelite augyte.
b. Haüynophyre.
c. Allogovyte.
d. Common augyte.
e. Anamesyte.
f. Basalt.
g. Porphyritic basalt.
h. Amygdaloidal basalt.
i. Basalt lava.
j. Variolitic basalt.

B. Leucityte.
Var. *a*. Compact leucityte.
b. Leucitophyre.
c. Amygdaloidal leucityte.
d. Leucityte lava.

Group K.—Volcanic Tufa and Peperino (Ingenite in part, derivate in part).

Subgroup *A*. Tufa.
Var. *a*. Trachyte.
b. Pumiceous.
c. Phonolyte.
d. Pozzuolana.
B. Peperino.
Var. *a*. Augyte.
b. Leucityte.
c. Palagonyte.
C. Volcanic conglomerate.
Var. *a*. Volcanic breccia.
b. Volcanic agglomerate.

Class IV.—TRANSITION OR METAMORPHIC SEDIMENTARY ROCKS.

Group L.—GNEISS.
Subgroup *A*. Felspathic and felsitic gneiss.
Var. *a*. Orthoclase gneiss.
b. Oligoclase gneiss.
c. Alpinyte.
d. Adularia gneiss.
B. Micaceous gneiss.
Var. *a*. Two-mica gneiss.
b. White mica gneiss.
c. Black mica gneiss.
C. Quartzitic gneiss.
D. Basic gneiss.
Var. *a*. Hornblendic gneiss.
b. Chloritic gneiss.
c. Talcose gneiss.
d. Protogene gneiss.
E. Iolitic gneiss.
F. Hematitic gneiss.
G. Graphitic gneiss.
H. Common gneiss.
Var. *a*. Compact gneiss.
b. Slate gneiss.

Var. *c.* Ribaned gneiss.
d. Fibrous gneiss.

Subgroup *I.* Oblique gneiss.
Var. *a.* Curled gneiss.
b. Nodular gneiss.
c. Conglomeritic gneiss.

J. Porphyritic gneiss.
K. Granitoid gneiss.

Group M.—SCHIST.

Subgroup *A.* Argillyte.
Var. *a.* Chiastolitic schist.
b. Phyllitic schist.
c. Carbonaceous schist.
d. Alum schist.
e. Spilyte.
f. Dolomitic schist.
g. Folded argillyte.
h. Contorted argillyte.
i. Fibrous argillyte.

B. Quartzyte.
Var. *a.* Itacolumyte.
b. Itabiryte.
c. Felsitic quartzyte.
d. Quartz rock.
e. Fibrous quartzyte.
f. Conglomeritic.

C. Felsyte schist.
Var. *a.* Micaceous.
b. Quartzose.
c. Pyritous.
d. Ribaned.
e. Mealy.
f. Gneissoid.

D. Mica schist.
Var. *a.* Two-mica schist.
b. Chloritic.
c. Talcose.
d. Garnetiferous.
e. Chiastolitic.
f. Andalusitic.
g. Amphibolic.

Var. *h.* Epidotic.
i. Quartzose.
j. Felsitic.
k. Calcareous.
l. Schorlaceous.
m. Pyritous.
n. Pyrrhotitic.
o. Hematitic.
p. Graphitic.
q. Fine.
r. Ribaned.
s. Fibrous.
t. Nummoid.
u. Wavy.
v. Frilled.
w. Curled.
x. Knotty.
y. Nodular.
z. Gneissoid.

Subgroup *E.* Basic schist.
Var. *a.* Hornblende schist.
b. Actinolite.
c. Chlorite.
d. Chloritoid.
e. Potstone.
f. Talc schist.
g. Garnet.
h. Tourmaline.
i. Rhætizitic.

F. Metallic schists.
Var. *a.* Mico-iron schist.
b. Pyrite schist.
c. Pyrrhotite schist.

G. Burnt shale.
Var. *a.* Burnt clay.
b. Rock slag.
c. Porcelanyte.

H. Minerals forming rock masses (*see* page 22).
Var. *a.* Quartz.
b. Corundum.
c. Apatite.
d. Magnesite.

Var. *e.* Orthoclase.
f. Pistacite.
g. Pycnite.
h. Lepidolite.
i. Lievrite.
j. Magnetite.
k. Anthracite.
l. Graphite.
m. Eisenkiesel.
n. Garnet-rock.

Group N.—Slate. [See Order II., Class I., Group A, Subgroup *B*, Variety *d*.]

Group O.—Calcareous Rocks.

Subgroup *A*. Schistose limestone.
Var. *a.* Cipollino.
b. Calciphyre.
c. Hemitrene.
d. Felsitic limestone.
e. Statuary marble.
f. Granular schistose limestone.

Group P.—Pseudomorph Calcareous Rocks.

Subgroup *A*. Schistose dolomyte.
Var. *a.* Micaceous dolomyte.
b. Pyritous.
c. Saccharoid.
d. Granular.
B. Ophyte.
Var. *a.* Ophidolomyte.
b. Ophimagnesyte.
c. Ophicalcyte.
d. Ophyte schist.
C. Steatyte.
Var. *a.* Felsitic steatyte.
b. Hornblendic.
c. Pyroxenic.
d. Micaceous.
e. Steatyte schist.
f. Pyrallolyte.
g. Onkosin.
D. Magnesyte.
E. Smaragdite schist.

Order No. II.—*DERIVATE ROCKS.*

(*Divided into Classes, Groups, Subgroups, Varieties, and Subvarieties.*)

Class I.—SUBAQUEOUS ROCKS.

Group A.—ROCKS FOR THE MOST PART MECHANICALLY FORMED.

Subgroup *A*. Arenaceous rocks.

Var. *a*. Sand, gravel, and shingle.

b. Conglomerate.

Subvar. a. Calcareous.
b. Hematitic.
c. Cupriferous.
d. Pyritous.
e. Plumbeous.
f. Shale conglomerate.
g. Slate conglomerate.

c. Breccia.

Subvar. a. Calcareous.
b. Hematitic.
c. Cupriferous.
d. Pyritous.
e. Shale breccia.

d. Sandstone and grit.

Subvar. a. Calcareous.
b. Argillous.
c. Felspathic.
d. Micaceous.
e. Hematitic.
f. Cupriferous.
g. Pyritous.
h. Tuffose.
i. Pebbly.
j. Cleaved.
k. Oblique.
l. Concretionary.
m. Spheroidal.
n. Nodular.
o. Lenticular.
p. Friable.

Var. *e.* Flagstone.
Subvar. a. Arenaceous.
b. Argillous.
c. Slabstone.

Subgroup *B.* Argillous or Argillaceous rocks.
Var. *a.* Clay, loam, mud, and silt.
Subvar. a. Kaolin.
b. Potter's clay.
c. Brick clay.
d. Fire clay.
e. Clunch.
f. Claystone.
g. Clayrock.
h. Lateryte.
i. Fuller's earth.
j. Bituminous clay.
k. Saliferous clay.
l. Variegated clay.
m. Hematitic clay.
n. Ferruginous clay.
o. Book clay.

b. Marl.
Subvar. a. Calcareous.
b. Dolomitic.
c. Argillous.
d. Arenaceous.
e. Micaceous.
f. Oil-slate.
g. Glauconitic.
h. Gypseous.
i. Shell marl.
j. Mealy marl.
k. Marl-stone.
l. Tutenic marl.
m. Book marl.

c. Shale.
Subvar. a. Calcareous.
b. Arenaceous.
c. Micaceous.
d. Bituminous.
e. Carbonaceous.
f. Hematitic.
g. Cupriferous.

Subvar. h. Flaggy.
i. Conglomeritic.
j. Nodular.
k. Concretionary.
l. Spheroidal.
m. Lenticular.
n. Mudstone.
o. Tutenic shale.

Var. *d.* Slate.

Subvar. a. Roofing slate.
b. Slab slate.
c. Pencil slate.
d. Novaculyte.
e. Calcareous slate.
f. Carbonaceous.
g. Arenaceous.
h. Tuffose.
i. Ribaned.
j. Conglomeritic.

Subgroup *C.* Fault rock.

Group B.—ROCKS FOR THE MOST PART CHEMICALLY FORMED.

Subgroup *A.* Halyte.

Var. *a.* Granular.
b. Sparry.
c. Fibrous.

B. Gypsum.

Var. *a.* Alabaster.
b. Granular gypsum.
c. Compact.
d. Fibrous.
e. Selenyte.
f. Tripe-stone.

C. Anhydryte.

Var. *a.* Granular.
b. Compact.
c. Fibrous.

D. Dolomyte.

E. Quartz.

Var. *a.* Chert.
b. Flint.
c. Menilyte.
d. Jasper.

Var. *e.* Agate.
f. Basanyte.

Subgroup *F.* Limonite rock.
Var. *a.* Limonite shale.
b. Oolitic brown ore.
c. Reniform iron ore.
d. Pea-iron ore.
e. Bog-iron ore.
Subvar. a. Black.
b. Yellow.
c. Sparry.

G. Hematite rock.
Var. *a.* Red iron-mould.
b. Reddle.
c. Sparry red-ironstone.
d. Specular iron.
e. Topanhoacanga.

H. Spherosideryte.
Var. *a.* Black band.

I. Minerals occurring as rocks (*see* page 17).
Var. *a.* Asphalte.
b. Pyrite.
c. Cinnabar.
d. Boracite.
e. Trona.
f. Aragonite.
g. Manganese ores.
h. Rhodochrosite.
i. Bole.
j. Opal.
k. Fluorite.
l. Barite.
m. Ankerite.
n. Malachite.
o. Melanite.
p. Galmey.
q. Zincite.
r. Galenite.
s. Stibnite.
t. Arsenopyrite.
u. Sulphur.
v. Wavellite.
w. Chalcopyrite.

Group C.—ROCKS PARTLY MECHANICALLY, PARTLY CHEMICALLY, AND PARTLY ORGANICALLY FORMED.

Subgroup *A*. Laminated, or stratified coal.

Var. *a*. Cannel coal.

Subvar. a. Parrot coal.
b. Horn coal.
c. Torbanyte.

b. Splint coal.
c. Culm.
d. Bituminous shale.
e. Carbonaceous shale.

Subvar. a. Batt, or bass.
b. Dauks.
c. Kelve.
d. Pindy.
e. Slaty culm.

B. Limestone.

Var. *a*. Compact limestone.
b. Crystalline limestone.
c. Marble.
d. Oolyte.

Subvar. a. Pisolyte.
b. Dolomitic oolyte.

e. Chalk.

Subvar. a. Indurated chalk.
b. Chalk rock.
c. Pisolitic chalk.
d. Glauconitic chalk.
e. Ferruginous chalk.

f. Calcsinter.

Subvar. a. Travertine.
b. Stalactyte.
c. Stalagmyte.
d. Rockmeal.

g. Coral-reef limestone.
h. Brecciated limestone.
i. Limestone conglomerate.
j. Rubbly limestone.
k. Lithographyte.
l. Siliceous limestone.
m. Cherty.
n. Argillous.
o. Arenaceous.

Var. *p.* Ferruginous.
q. Bituminous.
r. Stinkstone.
s. Dolomitic limestone.
t. Hydraulic limestone.

Subgroup *C.* Dolomyte.
Var. *a.* Granular.
b. Oolitic.
c. Compact.
d. Porous.
e. Cellular.
f. Concretionary.
g. Brecciated.
h. Rubbly.
i. Ferruginous.
j. Argillous.
k. Arenaceous.
l. Siliceous.
m. Cherty.
n. Tuffose.
o. Dolomitic sand.

D. Marine drift.

(*See* Class II., Subgroup *B*, Var. *c.*)

Class II.—SUBAERIAL ROCKS.

Group D.—MECHANICALLY, CHEMICALLY, OR ORGANICALLY FORMED.

Subgroup *A.* Coal.
Var. *a.* Peat.
Subvar. a. White turf.
b. Brown turf.
c. Black or Stone turf.
d. Gas turf.

b. Lignyte or Brown coal.
Subvar. a. Woody lignyte.
b. Compact lignyte.
c. Jet.

c. Black coal or Steinkohle.

Subvar. a. Caking coal.
b. Non-caking coal.
c. Cherry coal.

Var. *d.* Anthracyte.
Subvar. a. Native coke.

Subgroup *B.* Surface deposits and accumulations.
Var. *a.* Boulder-clay-drift.
Subvar. a. Calcareous.
b. Argillous.
c. Arenaceous.

b. Moraine drift.
Subvar. a. Calcareous.
b. Argillous.
c. Arenaceous.
d. Rocky.

c. Sand, gravel, and shingle.
Subvar. a. Esker drift.
b. Post-drift gravel.
c. Beaches.
d. Æolian drift.
e. Shell sand.
f. Bergmehl.

d. Guano.
e. Soil.
f. Meteoric drift.
g. Ice.

PART II.

Order I.—*INGENITE ROCKS.*

Class I.—GRANITIC ROCKS.

THE typical rock of this class is a crystalline aggregate of quartz, felspars, and micas, nearly universally known as granite or granyte [Celtic *gran*, Lat. *granum*, a grain.]* There are, however, rocks called granite in which part of the mica is replaced by other minerals, sometimes to such an extent that the mica is only microscopically visible.

Granite usually is a quaternary or quinary aggregate, containing, along with quartz, one or two felspars and one or two micas; nevertheless, other minerals are often present, more especially pyrite and marcasite.† Some granites are undoubtedly intrusive, while others appear to be only in part intrusive, portions having been formed *in situ;* that is, having relations as to position with the associated rocks similar to those which now exist. Typical granites weather with a peculiar rough, rugged aspect.

* In Cornwall granite formerly was called *growan*, from *gronen*, a grain.

† Some of the granites that weather or disintegrate freely appear to have marcasite as an ingredient disseminated in minute grains throughout the mass.

A. **Intrusive Granite; Highly Siliceous Granite;** *Leinster Granite; Oughterard Granite* [intruded into the place it now occupies]. — An aggregate of quartz and orthoclase with black and white mica; pyrite and marcasite are often constituents; while Haughton seems to believe that most, if not all, intrusive granites also contain albite.

NOTE.—Haughton finds the intrusive granites of Cornwall, Devon, Leinster, and Ulster, to contain "quartz, orthoclase, margarodite, and lepidomelane." He has also detected albite.

Varieties in Composition.

A. PYRITOUS INTRUSIVE, or HIGHLY SILICEOUS GRANITE. — When pyrite or marcasite is a component, galenite and chalcopyrite often occur as accessories.

a. Beresyte, Beresite.—Pyritous highly siliceous granite containing *gold.*

B. ALBITIC GRANITE (Dana).— Containing albite as well as orthoclase.

C. SCHORLACEOUS GRANITE. — With tourmaline (*schorl*) in addition to the mica.

In the highly siliceous or intrusive granite, as also in all granite, and some of the other ingenite rocks, are veins of segregation, which in the granites generally form two distinct varieties. One kind appears as irregular veins, nests, or patches, that have no deep-seated source, but die out every way, often in very short distances. The other variety makes regular, often dyke-like, veins, from half an inch or less in thickness, to about two or three yards in width. These latter appear to have segregated from the deep-seated fluid or semi-fluid portions of the mass, and to have been forced up into

the vacancies or the *shrinkage fissures* caused by the contraction consequent on the consolidation of the cooled portion or crust of the mass. The granite in such veins would necessarily be more siliceous than the granite mass through which they traverse, as basic rocks, although they melt at a lower temperature than the more siliceous, cool sooner and at a higher temperature, losing their heat much more rapidly. Consequently, it appears evident that the portions of a mass of granite which remain longest fluid ought to be more siliceous than the parts that cool first. The dyke-like *veins of segregation* are undoubtedly more siliceous than the rock which they traverse. Moreover, they are more compact, and finely crystalline. These latter peculiarities may, however, be due to the final rapid cooling when in the veins.

NOTE.—M'Farlane thus writes on the cooling of siliceous rocks :—"The scoria of iron-furnaces are usually very acid, containing as much as sixty per cent. of silex. They generally fuse at a temperature of 1,450° C. As they flow out of the breast of the furnace, they may be observed to do so very leisurely, to be sluggish and viscid, but nevertheless to continue fluid a long time ; and even, in some cases, to flow out of the building in which they have been produced, before solidifying. On the other hand, slags from certain copper-furnaces, or from those used for puddling iron, are more or less basic, containing from thirty to forty-five per cent. of silica. As they flow out they are seen to be very fluid, and to run quickly, but they solidify much more rapidly than iron slag. Yet these basic slags fuse at 1,300° C., or about 150° less than the more acid slags. Those who have been accustomed to observe metallurgical processes will not find it difficult to conceive how a very siliceous slag might continue fluid at a temperature at which a more basic one might become solid."

They often are more or less felsytoid; that is, have the aspect of a felstone or felsyte; but they always contain mica as a constituent, although often

only visible under the lens or microscope. On account of their similitude in aspect to felsyte, also on account of their usual purplish reddish colour, Delesse and others erroneously call them "eurites," although they are quite dissimilar to the original *eurytes* of Daubuisson. Rose, on the other hand, describes a granite apparently identical with them, and calls it *granityte*, a name to which there seems to be no objection.

D. GRANITYTE; GRANITITE (Rose).—A compact finely crystalline rock, usually purplish or reddish purple in colour. An aggregate of felspar (orthoclase), quartz, and mica. Black and white mica seem always to be present, but often in such minute flakes as to be only microscopically visible. Pyrite, and sometimes marcasite, are locally present.

Granityte* occurs as veins in granite from mere lines to two or more yards in thickness. It seems to be allied to *elvanyte* or *quartz-porphyry*, hereafter described, as sometimes part of the quartz in the granityte seems to have crystallized out prior to the other constituents. Moreover, granityte nearly always weathers evenly like those rocks, and not with the rugged uneven surface, so characteristic of typical granite.

Allied to the intrusive granite are rocks that to the naked eye seem not mineralogically granite, yet petrologically they seem to be part of the intrusive granite, as they always occur associated

* If granityte, as suggested, fills cracks and fissures in the granite, it and elvanyte must necessarily have cooled under somewhat similar conditions. Jukes has described some of the granitytes of the counties of Wicklow and Dublin, Ireland, as elvanytes.

with it, into which they seem to merge, and it into them. They are as follows :—

E. Felsitic Granite (King); Felsite Rock (Cotta). —"A rock of compact texture, about the hardness of felspar, with dull or smooth conchoidal or fissile fracture; colour yellowish, reddish, grey, greyish, or bluish, weathering white."—*Cotta.*

To the naked eye this rock does not appear to contain either mica or quartz; however, with a lens, both of these substances can be detected, but usually they appear to be sparingly and partially developed.

F. Greissen; Quartzitic Granite.—Apparently a crystalline granular aggregate of quartz and mica.

Greissen occurs associated with the intrusive granite, and merges into it. Sometimes, indeed, there is felspar developed, but so sparingly and at such wide intervals, that it seems to be more an accessory than an essential of the rock. In some places even the mica seems to be absent, or in such minute particles as only to be detected by a microscopical examination.

Structural Varieties.

G. Porphyritic Intrusive, or Highly Siliceous Granite.—In which crystals of felspar are largely and conspicuously developed.

H. Pegmatyte; Pegmatite [Gr. *pegma*, a hardened mass].—The second variety of the veins of segregation; very coarsely and irregularly crystallized, the conspicuous constituents, according to Cotta, being "orthoclase, quartz,

and silvery-white mica." Nevertheless, it usually also contains more or less dark-coloured mica, also pyrite or marcasite, and locally tourmaline.

Pegmatyte sometimes appears in large, well-marked veins, but more frequently it occurs in irregular veins, patches, and lentils, dying out in every direction. The dark-coloured mica, although the other constituents may be very coarsely crystalline, usually occurs in minute scales, but not always.

a. Graphic granite [Gr. *grapho*, I write].—A variety of Pegmatyte, in which the constituents are so arranged as to produce figures resembling written characters.

b. Blumen granite.—"The felspar assumes a form resembling flowering-stalks."—*Cotta.*

c. Plumose granite. — The mica assumes a plumose form, like Prince of Wales's feathers. —*Jukes.*

The granites belonging to this type [intrusive granite] in general are not foliated; nevertheless Forbes mentions a "foliated granite" at Edisvand, Norway; of which he says: "No doubt could be entertained of its true eruptive origin." And my colleague, Mr. R. G. Symes, describes veins of a foliated granite which he observed N.E. of Castlebar, in the co. Mayo, Ireland. In south-west Mayo, associated with very slightly metamorphosed rock, are wide dykes of foliated rock, some being typical gneiss (leaves of quartz, felspar, and mica), others hornblendic gneiss, while some apparently are formed of leaves of quartz, orthoclase, and amphibole.

Not uncommon in the intrusive granite is a structure having an aspect somewhat like foliation; and yet it cannot be so classed, as the con-

stituents of the rock have no tendency to occur in leaves. Perhaps it may possibly be some kind of close, irregular, rudely parallel-jointed structure, induced during the cooling of the rock, somewhat similar to the structure called by Scrope "shrinkage fissures." This structure of the intrusive granite is scarcely perceptible in a hard specimen, but in rock masses it is conspicuous.

Granites more or less due to metamorphism, having (for the most part) been altered into granite while in their present positions as regards the associated rocks (see *note, page* 7).

These rocks appear to have been formed from previously existing sedimentary and igneous rocks. Those due to the metamorphism of the sedimentary and of the basic-igneous rocks, are often very similar in aspect and composition, while some of the acid-igneous rocks have changed into granite somewhat similar to the *Intrusive Granite* (A).

B. **Granite for the most part non-intrusive; Basic or Oligoclase Granite**; *Scandinavian Granite* [in part metamorphic].—Usually a crystalline aggregate of quartz, black and white mica, orthoclase, and oligoclase. When typical, it is a quinary granite; however it is very variable in its composition, which in part seems due to its metamorphic origin. Many minerals occur locally as adjuncts; such as amphibole, titanite, ripidolite, pyrite, marcasite, &c., forming different varieties.

NOTE.—Haughton is of opinion that the normal constituents of this class of metamorphic granite in Ireland, Scotland, Norway, Sweden, and Finland, are *Quartz, Orthoclase, Oligoclase, Margarodite,* and *Lepidomelane.*

Varieties in Composition.

A. HORNBLENDIC GRANITE.—An oligoclase granite, in which amphibole is a constituent.

a. Titanitic Granite; Furbogh Granite.
b. Chloritic or Ripidolitic Granite.
c. Talcose Granite.
d. Epidotic Granite.

With amphibole titanite sometimes occurs, and this variety has been called *Furbogh Granite*, from a district in the county Galway, Ireland. In places ripidolite, talc, or epidote may be present with, or in place of, the amphibole, making varieties. The last-named mineral is supposed to be due to secondary formation.

NOTE.—*Hornblendic granite* by some geologists has been called "Syenitic granite." This name, however, seems not only unscientific, but also inapplicable, as the rock is not an aggregate of granite and syenyte, but of granite and amphibole [*hornblende*], and it is to the latter mineral that the name is intended to direct attention. *Chloritic granite* and *Talcose granite* have erroneously been called "Protogene granite," also a most incorrect name, as protogene (*quartz+felspar+talc*) is a constituent of neither. Furthermore, in general chloritic granite can have no relation to protogene, not containing any talc.

B. GRAPHITIC GRANITE.—With graphite in addition to mica.

C. HEMATITIC OR FERRUGINOUS OLIGOCLASE GRANITE.—With micaceous iron-ore in addition to the mica.

D. PYRITOUS OLIGOCLASE GRANITE. — Containing pyrite or marcasite, or even chalcopyrite, in addition to the other constituents.

Structural Varieties.

E. Porphyritic Oligoclase Granite; *Galway Granite.*—Having one of the felspars developed in crystals, larger and more conspicuous than those of the other constituents. Generally, it is the orthoclase that is porphyritically developed; however, sometimes it is the oligoclase. It is the typical granite of county Galway, Ireland.

F. Gneissoid Granite; Foliated Granite; *Gneissic Granite* (Cotta).—An oligoclase granite, in which there is more or less distinct foliation. Sometimes one of the felspars is porphyritically developed, when in general the mica does not curl round the large crystals of felspar, but the latter lie promiscuously about.

a. Nodular Granite.—Containing round or semi-angular pieces or nodules of a dissimilar granite or of a granitic rock. The inliers often are a hornblendic granite or a rock, like minette, or like a gneissyte, but they vary considerably.

b. Lenticular Granite.—A more or less gneissoid granite, containing lenticular patches or lentils of granite or a rock, like a gneissyte or minette. The lentils sometimes occur closely together, at other times widely apart; but in all cases the foliation of the rock curls round them.

G. Intrusive Oligoclase Granite; *Omey Granite.*—Very similar to the non-intrusive oligoclase granite; but such minerals as amphibole, titanite, ripidolite, &c., only occur locally, as accessories. It has been called "Omey granite," from an island on the west coast of Ireland.

Besides the varieties mentioned above, others

might be named, but those given seem to be the most important.

Veins of segregation occur in the oligoclase granite. Their composition appears very similar to the veins of segregation (*granityte*) that occur in the highly siliceous granite, being of a more or less siliceous nature. There are also irregular veins, nests, and lenticular patches, sometimes of considerable size, of a rock answering Cotta's description for the rock called *Pegmatyte*. The Pegmatyte found associated with the non-intrusive oligoclase granite is, at least in some instances, due to the metamorphism of irregular felspathic veins and lenticular patches that existed in the metamorphosed sedimentary and irruptive rocks prior to their being changed into granite.

Basic igneous rocks may be metamorphosed into rocks very similar to the *Basic* or *oligoclase granite*, or its varieties; and the Acid or highly siliceous igneous rocks may change into a rock like the finer varieties of the *Intrusive* or *highly siliceous granite* (A); while the basic felstones (*Euryte and such rocks*) may be altered into more or less hornblendic or chloritic, or even talcose granite.

H. Granitic Felstone.—A fine, more or less even-grained aggregate of quartz, felspar, and mica. In some varieties the felspar seems always to be orthoclase; the mica may be black or white, often both. Part of the mica may be replaced by amphibole or ripidolite. They weather neither like a true granite nor yet like a felstone, having a characteristic weathering of their own, partaking of the nature of both.

Granitic felstones probably are metamorphosed felstones. They are often banded, the lines some-

times being parallel, or nearly so, to the walls of the dykes, but at other times they are oblique. The bands are due to thin zones of different colour or texture, perhaps also of composition. In these bands, or between them, there is on rare occasions a structure like foliation.

All the metamorphosed igneous rocks are more or less granitoid, in accordance with the intensity of the metamorphism that has acted on them and the associated sedimentary rocks.

C. **Protogene** [Gr. *protogenes*, first formed; the rock, when first discovered, being supposed to be the oldest].—A granitoid rock; a crystalline aggregate of quartz, felspar, and talc.

Protogene, although not a true granite, seems allied to those of the *Oligoclase type* (B). The name is said to have been given originally to a metamorphic rock, but its original signification appears to have been lost, for Cotta thus describes it:—"A granite which contains talc or chlorite, or decomposed mica, instead of the usual mica." This is an erroneous definition, for if it contains either mica or ripidolite instead of talc, it cannot be Protogene.* However, Cotta would appear not to be the only geologist or petrologist who has found this rock a stumbling-block; as Haughton, after examining numerous specimens of the so-called Protogene from the Alps, states that most of them "contained not talc, but dull mica or ripidolite, or some kindred mineral." If a rock contains mica in addition to talc, or ripidolite in place of talc, it cannot be protogene, but is, in the one case, *Talcose Granite*, and in the other, *Chloritic* or *Ripidolitic Granite*.

* Some basic felstones, when metamorphosed, appear to be true protogene (quartz+felspar+talc).

The formation of granite is not fully understood; yet I cannot but believe that while some are undoubtedly intrusive, others have been formed by extreme metamorphic action. However, between the two extremes there is a rock (previously mentioned and described as *Intrusive oligoclase granite*) that partakes of the nature of both, having constituents very similar to the ordinary oligoclase granite, while it is intrusive, like the highly siliceous granite. This at first may appear an anomaly; nevertheless it seems capable of a simple explanation.

All authorities infer that granites were formed at a considerable depth beneath the earth's surface, under pressure, by extreme heat. They cooled and consolidated, more or less gradually, long previous to coming near, or being exposed at the surface of the earth.

Rocks, under the above conditions, would melt more or less rapidly in accordance with the intensity of the heat to which they were subjected, the amount of pressure, and constituents of which they are composed. Moreover, the more acid portions would remain longer fluid, during refrigeration, than the basic (*see* page 28).

If, while in a state of fusion, the heating action were to cease or begin to subside (either of which must at some time have happened), the rocks or strata affected would be in the following conditions: Part would be entirely fused or liquefied; part would be semifused; while the rocks adjacent to the latter would be only more or less altered. Of the latter class, the least altered rock would be represented by rocks belonging to the *Schist series;* while the more altered rocks, according to the intensity of the metamorphic action, would form the *Gneiss*

series and the *Gneissoid granite.* The second class, or the semifluid rocks, would form the *Oligoclase granite,* or the *Granite due to extreme metamorphism;* while the first class, or the completely fluid mass, would form the different intrusive or irruptive rocks.

Of the completely fluid mass, part ought to find its way to, or close to, the earth's surface, and then cool under little or no pressure, forming the *Plutonic* and *Volcanic rocks;* a portion would consolidate between the source, the caldron, if it may be so called, and the surface of the earth, under more or less pressure, and form *Elvanyte* or *Quartz-Porphyry,* the granitic rocks next to be enumerated and described; while the residue would consolidate in or near the caldron.

The consolidation of the residue, that remained in or near the caldron or source, could scarcely have been simultaneous, as it is probable the outer or upper portion would consolidate sooner than the inner or lower part. Moreover the acid portion would consolidate slower than the basic part; consequently there ought to be two distinct rocks forming,—a more basic rock above, and a more acid or siliceous rock below. As the upper or more basic rock cooled and consolidated, it ought to shrink more or less, and thereby form cracks, fissures, and other vacancies, into which the underlying still fluid or semifluid matter would be squeezed; therefore at any time prior to their final consolidation, part of the *oligoclase granite* or part of the *highly siliceous granite* might be forced up into and occupy all vacancies in the supercrescent rocks, and thereby form *intrusive* granite of one or both types (*Intrusive oligoclase granite* and *Intrusive*

highly siliceous granite) ;—subsequently, when the overlying rocks were denuded away, tracts, veins, &c., of these granites would be exposed.

The above suggestions, if correct, give a solution for the formation of the three different kinds of granite,—Highly siliceous granite, Intrusive oligoclase granite, and the Non-intrusive oligoclase granite. The Non-intrusive oligoclase granite would be represented by the semifluid portion that first consolidated; the Intrusive oligoclase granite by the more basic portion of the fluid mass that was forced out of its normal position; while the Highly siliceous granite would be the part that took longest to cool and consolidate. That granite must cool and consolidate under laws somewhat similar to the above appears highly probable, because when two or more granites come from one source, the last formed is more siliceous than the rock through which it breaks up, while the veins of segregation in the former are more siliceous than the parent rock in which they appear.

D. **Elvanyte** (Jukes); **Quartz-Porphyry**; **Quartziferous Porphyry**; *Granitic Porphyry* (Cotta), [Celtic, *el* or *oil*, rock, and *van* or *ban*, white, so called from the white crust of the rock when weathered].—A granitic rock, having a granular or compact felsitic or felspathic matrix, inclosing globules, blebs, and crystals of quartz, crystals of one or more felspars, with more or less mica or amphibole, ripidolite, and the like. Pyrite and marcasite are often constituents. In many of the siliceous varieties, a considerable portion of the quartz crystallized out prior to the other minerals. The matrix may be siliceous (*felsitic*) or basic (*fel-*

spathic), and of a greenish, greyish, brownish, blackish, bluish, or even yellowish colour: all of the yellowish, as also some of the blues, seem due to weathering.

NOTE. — Elvanyte naturally includes not only the quartz-porphyries, but also the syenytes (quartz+felspar+amphibole) of some British geologists.

The free silica or quartz in the Elvanyte is for the most part in irregular blebs or globules, from minute specks to the size of a pea, or even larger. The quartz internally has a glassy, often radiated structure, and externally on some, the crystal faces can be recognized, while others appear to be regular coated minute balls. The quartz is scattered through the mass, sometimes sparingly, but at other times so thickly as to give the rock a pisolitic aspect. Elvanytes, except some of the very granitic varieties, weather with the even flowing surface so characteristic of the Felstones, and not with the rough rugged aspect of granite. They often near the edge of large masses, at the walls of dykes, and in small branch dykes or veins merge into a rock in appearance identical with felstone: this compact rock is called by Cotta *the Base* or *Mother-rock*. The Mother-rock at dyke walls is rarely more than a few inches thick. Elvanytes being hypogene rocks, are never accompanied by *tuff*.

NOTE.—A true elvanyte is more crystalline at the centre of a dyke or mass than at the margins, while an elvanoid rock due to metamorphism is more crystalline at the margins than in the interior, the change in the latter taking place from the outside inwards.

Varieties in Composition.

A. Felsitic and Felspathic Elvanyte. — Respectively a siliceous or a basic elvanyte, in which the quartz, mica, and other minerals are more or less developed.

a. Orthoclasic Elvanyte. — When the felspar is principally orthoclase.

b. Oligoclasic Elvanyte.—When the felspar crystals are principally oligoclase.

c. Rappakivi Elvanyte.—An elvanyte in which many of the orthoclase crystals (often pink or flesh-colour) are inclosed in an envelope of oligoclase (often light green). In the Finland variety the orthoclase is generally in rounded masses inclosed in orbicular envelopes of oligoclase.

B. Quartzitic or Siliceous Elvanyte.—Having a large percentage of siliceous matter.

C. Micaceous Elvanyte.—Having a large percentage of mica.

Note.—These rocks would be called "mica traps" by some authors. (See *Mica Trap*, page 48.)

D. Pyritous Elvanyte. — Having a large percentage of either pyrite, marcasite, or chalcopyrite.

E. Hornblendic Elvanyte.—When typical, a granitoid rock, an aggregate of quartz, felspar, and amphibole, usually with some pyrite or marcasite; it however graduates into more or less compact varieties.

Varieties in composition are, — *a. Micaceous; b. Chloritic; c. Felspathic; d. Pyritous;* respec-

tively, as different minerals give a marked character; some structural varieties are gneissoid.

NOTE.—Some authors would call hornblendic elvanyte and its varieties "syenyte." Part of a mass may be a true syenyte (*amphibole*+orthoclase+quartz), but in general the rock contains two felspars.

F. CHLORITIC OR RIPIDOLITIC ELVANYTE.—Having ripidolite replacing most or all of the mica or amphibole.

Structural Varieties.

G. GRANULAR ELVANYTE.—With a matrix somewhat resembling granite; but distinct crystals of one or more felspars, with globules, blebs, and crystals of quartz, flakes of mica, or crystals of amphibole, are separately and prominently developed. In one variety ripidolite replaces the mica or amphibole.

H. COMPACT ELVANYTE, or PONTELLARYTE.—The matrix is more or less compact throughout, forming a paste, often dark-coloured. It contains separate crystals, globules, or flakes of one or more felspars, amphibole, quartz, mica, or ripidolite.

I. GNEISSOID ELVANYTE.—Elvanyte with a structure that seems to be foliation, more or less well-defined. Some varieties are micaceous, others hornblendic; while some may be chloritic. Some gneissoid elvanytes may be metamorphosed igneous rock.

J. GRANITOID ELVANYTE.—For the most part an aggregate of quartz and felspar, with mica, or ripidolite, or amphibole. Part of the matrix appears as a sort of paste, while some of the

quartz occurs in globules, blebs, or irregular crystals, having crystallized out prior to the other minerals.

Most *granitoid elvanytes* weather more like a felstone than like a granite; some, however, do not. At the walls of dykes or masses they often merge into a more or less compact rock—"*The Mother-rock, or Base,*" of Cotta. Granitoid elvanyte seems to be the passage-rock between granite and elvanyte.

K. PYROMERIDE, or BALL ELVANYTE, *Ball Porphyry.*—"This rock, in addition to the usual quartz crystals, contains balls of felsite (either small and numerous, or large and isolated. The small balls are frequently marked internally with radial streaks. The interiors of the larger ones are usually split after the manner of septaria, or they contain a geodic cavity). The clefts or cavities in the balls are wholly or partly filled with hornstone, chalcedony, agate, quartz, amethyst, calcite, fluorite, &c. &c."—*Cotta.*

Class II.—PLUTONIC ROCKS.

THIS name (from *Pluto,* the god of the infernal regions) has been given to the rocks that at one time were buried beneath the earth or sea, as distinct from the Volcanic, or those that are thrown up and consolidated on the present surface of the earth. The Plutonic rocks were irrupted or intruded, and consolidated at or near a former surface of the earth, or at the bottom of a sea or lake, under, comparatively speaking, little pressure; but subsequently they were covered by successive

deposits of "Derivate rocks." As they are not "hypogene rocks," they have their tuffs, agglomerates, and other mechanically-derived associates, with which they may be interstratified, as also with any class or variety of derivate or sedimentary rock.

In Nature there are no hard divisional lines between different kinds of rocks, more especially ingenite rocks; therefore the Plutonic rocks, on one hand merge into Granitic rocks, and on the other into Volcanic rocks. A boundary between the Granitic and Plutonic rocks can be defined, as the first are hypogene, while the latter are not; but the difference between the Plutonic and the Volcanic rocks is much more vague, we only knowing that the latter are intrusive rocks, erupted and consolidated at the *present* surface of the earth, while the former were formed in ages or geological periods *long past*, and subsequently were covered up by accumulations of strata that are now in part removed by the force of denudation, thereby bringing them again to the surface.

E. **Felstone, Felsyte, or Felsite** [Ger. *felspath*, rock spar].—A compact or granular, or splintery quartzitic felspathic rock—often porphyritic or quartzose; sometimes micaceous, or hornblendic, or ripidolitic; pyrite or marcasite, and sometimes chalcopyrite, may occur as constituents.

The Felstones, or Felsytes, include all the highly siliceous plutonic rocks, and are for the most part a felsitic compound. Various minerals, however, are locally ingredients, forming numerous subgroups and varieties. Felstones, or Felsytes, usually weather in flowing surfaces with even outlines. They are, however, affected by different structures. Some are homogeneous; in some there is a platy arrange-

ment, rudely parallel to the walls of the dykes; while in others, sometimes, however, associated with the platy structure, is a spheroidal or concretionary arrangement. The platy structure may be due to the rock cooling in thin sections, or nearly vertical layers; or perhaps, as suggested by Scrope, to the differential motion of the vesicular and non-vesicular portions of the cooling rock. The spheroidal or concretionary arrangement seems always to occur near the end of a dyke, and may be due to the cooling when the rock was in its last stage of motion: Phillips, in his description of "Vesuvius," figures and describes a similar structure in some of the dykes of lava belonging to that volcano.

In other felstones, or felsytes, there are lines cutting obliquely across; while in some is a rudely columnar structure, except that the joint-planes are as often oblique as perpendicular to the walls of the dykes. Associated, in places, with the last-named is a very irregular platy development between the joint-lines usually perpendicular to them, but often more or less oblique.

The minerals most commonly appearing in Felstone or Felsyte, are—crystals of orthoclase, oligoclase, pyrite, marcasite, and amphibole, blebs or crystals of quartz, and flakes of black and white mica, and ripidolite. The quartz globules vary from minute particles to the size of a pea.

A. Petrosilex (Brongniart) [Lat. *petra*, stone, and *silex*, flint, on account of the hard matrix and flint-like appearance of the rock], *Felsyte*, or *Felsite*.—The type rock of the Felstones. A compact or granular, hard, siliceous felsitic rock; a granular mixture of felspar and quartz, in which, although fine-grained, the minera

constituents do not merge into one another, but are recognized by the eye, with or without the help of a magnifying-glass. Petrosilex is greyish, greenish, purplish, or bluish in colour; when yellowish or reddish, the colour seems due to weathering. Some are splintery, but usually they have from an uneven to a conchoidal fracture, and are translucent or subtranslucent. Some have a porcelanic, others a saccharoid aspect.

*a. Felstone glass; Pitchstone felsyte.** — "The principal mass is homogeneous; of vitreous pitch-like appearance; conchoidal fracture; resinous lustre; translucent at the edges, and very variously coloured."—*Cotta.*

b. Ribaned petrosilex; Striped, or *ribaned felsyte,* with bands of different colour, texture, and sometimes composition alternating. — In some varieties the rock splits into plates along the riban.

B. Quartzitic or Quartzose Felstone, or Felsyte; Quartziferous Felstone.—A compact felsitic mass, inclosing crystals or crystalline grains of quartz. Of quartzitic felstone there are different varieties; some due to composition, others to structure.

The compact matrix consists principally of felspar, and of it Cotta says: "Probably orthoclase; its proportion of silica is, however, too high even for orthoclase, and it is therefore probable that some quartz is intimately combined with the felspar." The colour of the matrix is greyish, greenish, purplish, or bluish, with the surface

* Pitchstone felsyte must not be confounded with the volcanic rock.

weathering a dirty white; when the rock is yellowish or reddish, the colour seems due to secondary action. The texture of the matrix varies considerably: sometimes it is compact like horn, with a smooth conchoidal fracture; at other times it is granular, or saccharoid, or splintery. Usually it is compact, with a fracture from semiconchoidal to uneven, but sometimes it is vesicular or amygdaloidal.

Varieties in Composition.

a. Oligoclasic quartzitic felstone; b. Micaceous; c. Hornblendic; d. Chloritic, or *Ripidolitic; e. Pyritous,* according to whichever mineral gives a character to the rock.

The micaceous varieties graduate into *Minette,* while other varieties graduate into *Felsitic elvanyte.*

Structural Varieties.

f. Striped, or *Ribaned quartzitic felstone.*—Thin layers of somewhat dissimilar texture; hence the fracture appears to be striped like a riban, and the rock splits more easily in the direction of those layers than across them.

g. Variolitic, or *Spotted quartzitic felstone,* containing in the matrix worm-shaped spots, or blotches of different colour, texture, and usually of composition.—In the latter case the rock weathers into pock-marked, or ovate hollows.

C. Minette, Micaceous Felstone, or Felsyte.—A more or less felsitic or felspathic rock, containing much mica, and sometimes distinct crystals of orthoclase or oligoclase, or amphibole.

a. Fraidronyte—Fraidronite.—" A greenish felspathic principal mass combined with a greater

or less quantity of mica. Pyrite and quartz occur as accessories."—*Cotta.*

NOTE.—MICA TRAP.—If the grouping of some recent writers were followed, the subgroup just described, and all other highly micaceous rocks, should here be introduced and described as *Mica traps.* Under this name, however, have been included "micaceous elvanyte," "micaceous felstone or minette," "micaceous euryte," "micaceous diabase or kersantyte," "micaceous dioryte or kersanton," "micaceous melaphyre," "micaceous doleryte," and many micaceous varieties of the above subgroups; rocks that are quite dissimilar, except that mica is largely developed in each. Mineralogically, such a group may exist, but geologically or petrologically it does not, for the different rocks which must be included under the name are varieties or subgroups not only of quite distinct groups, but also of distinct classes, for under it would be included granitic, plutonic, and volcanic rocks. Such a group will not be introduced into this Manual, but each micaceous rock will be found described in its natural group and place.

D. EURYTE, or EURITE [Gr. *eureo,* to flow well or easily].—A compact or granular felspathic rock, occasionally showing glistening specks of quartz in the mass, usually purplish or greenish in colour; may be vesicular or amygdaloidal; when heated before the blowpipe in thin pieces, it fuses with greater or less facility. It is often columnar.

In A.D. 1817 Daubuisson proposed the name *Eurite* for the basic felstones, on account of their fusibility. This name was afterwards, however, misapplied by Delesse and others, who called *Granityte* (veins of segregation in granite), by Daubuisson's name, apparently mistaking the rock, on account of Granityte being in colour and aspect somewhat similar to *Euryte.**

* A *Granityte* to the eye may appear the same as a *Petro-silex* or a *Euryte,* but if carefully examined will always be found to

Subsequently Naumann has proposed for Daubuisson's Euryte the name "Porphyrite," and Cotta advocates its adoption. It however seems to be a most objectionable name, as many authors use the term synonymously with porphyry.* Moreover, the name refers to a structure which is not an essential feature of the subgroup, or, to quote Cotta,— "*The name of Porphyrite refers to a texture which is not an essential feature of these rocks, because the Porphyrites are not always in fact porphyritic.*"

NOTE.—Intermediate between the highly siliceous felstones, or *felsytes*, and the *whinstones*, are rocks that partake more or less of the nature of both. These intermediate rocks Jukes and other British geologists seem to class with the basic rocks under the general name of Greenstone;† a name derived from the prevailing colour of the rocks, as even the purplish varieties have a green tinge, or merge into a green. One reason for this classification seems to be, that all the rocks included, fuse with greater or less facility before the blowpipe. Within the last few years there appears to be a reaction among some of the British geologists, who seem inclined to go to the other extreme, and place not only the eurytes, but also all the micaceous dolerytes, diorytes, and diabases in the Felstone group. This is evidently erroneous, as the latter rocks ought to be put with the basic rocks; or they and the eurytes should be placed in an intermediate group (called *Hybrid rocks* by Durocher) between the highly siliceous and the basic plutonic rock.

Varieties in Composition.

a. Orthoclasic euryte; b. Oligoclasic; c. Micaceous; d. Hornblendic; e. Chloritic, or *Ripidolitic; f. Quartzose.*

contain minute flakes of mica and a granular structure, never having the compact or semivitreous appearance characteristic of a *Euryte*.

* Its advocate, Cotta, seems to use it in this sense.

† Jukes, in his Manual, mentions that there are "intermediate rocks," but he does not name them.

The orthoclase and oligoclase appear as crystals, changing the rock into a *Porphyry;* the micaceous variety by some would be called a *Mica-trap,* and in the quartzose variety the quartz appears in blebs, globules, and crystals.

Structural Varieties.

g. Euryte porphyry; h. Amygdaloidal euryte; i. Vesicular; j. Compact; k. Slab or *flaggy euryte;* and *l. Cleaved;* according to the structure that gives a character to the rock mass.

The compact varieties have a conchoidal or subconchoidal fracture, while some of the cleaved rocks make a coarse roofing slate.

Structural Varieties of the Felstones.

E. COMPACT FELSTONE, or FELSYTE.—Typical felstone or felsyte (*see* Petrosilex).

F. GRANULAR FELSTONE, or FELSYTE.

G. FRIABLE, or MEALY FELSTONE.—A more or less fissile, or friable felstone; usually of a pale greenish or greyish colour; tough, but splits easily; a mealy or scaly aspect; often has a soapy feel, showing a transition into *Steatyte.*

This rock is undistinguishable in aspect and composition from some of the fine mealy *Felstone tuff.* It may possibly be a true tuff, but as it occurs in dykes and intrusive masses, and often graduates into a compact felstone, it is here described.

H. RUBBLY or SHINGLY FELSTONE; THICKLY-JOINTED FELSTONE.—So traversed by three or more regular or irregular systems of joint-lines, that the rock breaks up into rubble or angular shingle, and is incapable of being quarried in large pieces.

I. CLEAVED or SLATY FELSTONE.—With cleavage-planes, sometimes so distinct that the rock splits into slates, but rarely into "Roofing slate."

J. FOLIATED or SCHISTOID FELSTONE; SCHISTOSE FELSTONE.—A fissile felspathic rock, composed of leaves of felspar, with mica or amphibole, or ripidolite; sometimes with a little quartz.

NOTE.—Rocks very similar both in aspect and in composition are found among the metamorphic igneous rocks. Nevertheless it may be possible that some felstones are so constituted that on solidification their constituents arrange themselves in leaves. At Barna, co. Galway, Ireland, breaking up through the porphyritic oligoclase granite, are dykes belonging to this subgroup that apparently are newer than the time at which the general metamorphism of the associated rocks took place.

K. GRANULYTE, or GRANULITE.—"A fine-grained to compact fissile compound of felspar and quartz, usually with some mica."—*Cotta.*

NOTE.—Granulyte, although allowed to remain provisionally among the Felstones, may properly belong to the metamorphic igneous rocks, and be a felstone into which a fissile structure has been introduced by metamorphism. Some of the metamorphic igneous rocks hereafter to be described seem to be identical with the granulite of Cotta.

L. FELSTONE or FELSYTE PORPHYRY; PORPHYRY; ORTHOPHYRE.—Felstone, or Felsyte, containing distinct and numerous crystals of one or more felspars.

a. Amygdaloidal (Gr. *amygdalon,* an almond); *b. Vesicular.*

If the felsitic or felspathic matrix is full of cavities, the rock is called *vesicular,* while, if it contains crystalline secretions filling the original cavities, it is called *amygdaloidal.*

Felstones, or Felsytes, supposed to be metamorphosed.

Metamorphic action as yet has not been properly explained or understood. It cannot be denied that derivate rocks may be altered into schist and gneiss; yet many authorities seem to doubt that igneous rocks could be altered by the action that metamorphosed the others. That the latter have sometimes been altered, seems not only probable but also absolutely necessary, for the following reasons:—

There are derivate rocks of all ages, which have their associated igneous rocks. Such derivate rocks, except, however, those of the most recent age, are often metamorphosed; the metamorphism being clearly *normal* (to use Delesse's expression), *i.e.* not the result of the intrusion of the igneous rocks, although, as is often evident, effected after that intrusion. The agents which have prevailed to metamorphose the containing derivate rocks must unquestionably have attacked the contained igneous rocks, and that they have sometimes succeeded in altering them also more or less, seems clear from the circumstance, that the igneous inliers just mentioned are often different from any of those that occur in unmetamorphosed sedimentary rocks; which circumstance cannot be regarded as merely accidental.

In some localities, such as West Galway and Mayo, Ireland, there appear to be data for the above suggestions. In these places it has been observed that associated derivate and igneous rocks appear to have been acted on in similar ratio, as expressed in the following table: *

* This table only records changes that have been observed, not, however, all the changes rocks are capable of. The first stages of metamorphism of the Whinstones are so various, that it is hard to give a general name for the rocks.

UNALTERED ROCKS.	FIRST STAGE— METAMORPHISM.	SECOND STAGE— METAMORPHISM.	THIRD STAGE— METAMORPHISM.
Sandstone	Micacized sandstone	Schist	Gneiss.
Quartzose sandstone	Quartzite	Mica-schist	Gneiss.
Shale Slate	Argillyte	Mica-schist Chloritic schist	Gneiss.
Slaty or shaly tuff	Phyllitic schist	Hornblendic schist Talcose schist	Hornblendic gneiss.
Felsitic tuff	Felsitic schist Steatyte schist	Steatyte. Talc-schist.	
Mealy or friable felstone	Ditto	Ditto.	
Felstone	Schistoid felstone Granular felstone	Gneissoid felstone Micacized granular felstone	Gneissyte. Granite, or granitic felstone.
Euryte	Schistoid euryte	Gneissoid euryte	Syenyte. Hornblendic granite.
Whinstone		Dioryte Syenyte	Hornblendic granite.

M. GNEISSYTE or GNEISSITE; GNEISSOID FELSTONE.—A crystalline fissile aggregate of quartz, felspar, and mica, more or less foliated; always occurring in dykes or intrusive masses, associated with gneiss or schist.

NOTE.—Apparently this rock is the same as the rock described by Cotta, and called *Red Gneiss.*

Gneissyte generally does not occur among sedimentary rocks in the first stage of metamorphism * (*Schist series*), but among highly metamorphosed sedimentary rocks (*Gneiss series*); dykes and masses of it are often found.

Varieties in Composition.

a. Quartzose Gneissyte; b. Felsitic; c. Micaceous; d. Hornblendic; e. Syenyte Gneissyte; f. Chloritic or *Ripidolitic; g. Talcose Gneissyte.*

Varieties *d*, *e*, *f*, and *g* are probably metamorphosed eurytes. The difference between *d* and *e* is, that the former contains mica, in addition to amphibole, while in the latter there is only amphibole.

Structural Varieties.

h. Porphyritic, and *i. Schistoid.*

The latter variety splits easily along the planes of foliation, on account of one of the constituents, usually the mica or the quartz, being only very sparingly developed. It is the passage rock between gneissyte and schistoid felstone.

N. SCHISTOID FELSTONE or FELSYTE.—A fissile aggregate of felspar and mica; generally a little

* For the degrees of metamorphism of the derivate rocks see pages 37 and 76.

quartz is present, but in such small quantities as to seem more an accessory than an essential. The rock mass is more or less foliated.

Some schistoid felstones have an unctuous feel, and change by pseudomorphic action into *steatyte schist*, or even *steatyte*.

NOTE.—The foliation in the metamorphic felstones seems to follow conspicuous structures in the original rocks. Some normal felstones are amorphous, others have a spheroidal or platy structure, while some are cleaved. In the amorphous felstones there are often lines apparently due to viscid fusion, while in the platy felstones the lines are parallel, or nearly so, and at other times oblique to the walls of the dykes. In the metamorphic felstones very similar structural peculiarities can be found; in some there is little or no foliation, but the rocks are banded (see *Granitic Felstone*, page 35), while in some there is well-marked foliation, either parallel or oblique to the walls of the dykes, or spheroidal.

Schistoid felstones may be named after conspicuous minerals locally essential; they may be *quartzose*, or *felspathic*, or *micaceous*, or *hornblendic*, or *steatitic*, &c. &c.

F. **Whinstone**;* *Greenstone*.—A crystalline aggregate of felspar with either pyroxene, amphibole, or uralite. With these minerals, in forming subgroups and varieties, are associated ripidolite, mica, pyrite, marcasite. Under the group of Whinstone are

* The term Whinstone has been adopted in place of Greenstone, as the latter has different significations, according to the authority by which it is used. Jukes and many other British geologists include under that name not only the basic plutonic rocks, but also all the basic felstone, especially when of a green colour. Cotta includes under this name Dioryte and Diabase. Brongniart confines the term to Dioryte, while Naumann restricts it to Diabase. Whinstone seems to be a nearly universal name in England, Ireland, and Scotland, the only objection to it being that in places it is also applied to the basic volcanic rocks.

included all the very basic Plutonic rocks. They are usually dark-coloured, greenish or blackish; however, a few are light-coloured. The whinstones are often vesicular or amygdaloidal, and have their associated tuffs, with which they are often interstratified.

A. DOLERYTE [Gr. *doleros*, deceptive].—A tough aggregate, principally a mixture of felspar and pyroxene. Nearly always of a dark colour.

a. *White-rock* (Jukes).—A doleryte of a nearly white colour, found associated with coal in Staffordshire and elsewhere. The dykes of "white-rock" can be traced into masses of ordinary dark-coloured doleryte.

b. *Aphanyte-doleryte; Basalt.*—Very compact; often called "Basalt;" the latter name, however, ought to be only used for a variety of volcanic rocks.

B. MELAPHYRE.—A crystalline aggregate of felspar and pyroxene, with or without amphibole; of a dark colour, greenish, brownish, or blackish, with more or less resinous lustre; may be compact, porphyritic, vesicular, or amygdaloidal, and often contains specks of opal or quartz, also zeolites. Before the blowpipe it fuses readily; fracture uneven.

Varieties in Composition.

a. *Eukryte*, or *Eukrite.*—A crystalline granular aggregate of anorthite and pyroxene, occasionally with some olivine, amphibole, and epidote; the latter mineral being due to decomposition.

Peridolyte.—A subvariety in which olivine is always present.

b. Magnetic Melaphyre; having magnetite as a constituent. This rock may always be distinguished from *magnetic diabase*, as the magnetic constituent of the latter is pyrrhotite.

c. Micaceous Melaphyre.—The mica often is in considerable quantities.

Structural Varieties.

d. Porphyritic, containing felspar crystals; *e. Amygdaloidal; f. Vesicular;* and *g. Variolitic,* having spots of a different colour and texture, also perhaps of composition.

C. PYROXENYTE (Dana).—A compound of pyroxene and orthoclase.

D. DIABASE.—A crystalline granular aggregate of felspar, pyroxene, and ripidolite; colour usually greenish or purplish. The felspar is either oligoclase or labradorite, and frequently the latter. The pyroxene is diallage, and rarely ferruginous. The ripidolite is generally green, and in subordinate quantities; it is often only distinguishable with difficulty, from being in intimate admixture with the diallage.

Varieties in Composition.

a. Pyroxenic, or *Augitic Diabase,* having numerous and well-developed crystals of pyroxene, which, when weathered, give the rock a spotted appearance like a toad.

b. Uralitic Diabase, with numerous and well-developed crystals of uralite. In some subvarieties part of the pyroxene in the matrix is replaced by uralite. This rock, also, when weathered, has a spotted aspect.

c. Labradoritic; d. Oligoclasic; e. Magnetic, containing pyrrhotite; a micaceous subvariety, weathers freely into a magnetic sand; *f. Kersantyte* (Delesse), or *Micaceous;* and *g. Calcareous.*—"In a fine-grained or compact matrix of diabase rock are found small rounded grains of calcite, which do not apppear to be the fillings-up of cavities."—*Cotta.*

Structural Varieties.

If diabase contains numerous and well-developed crystals of felspar, it is called *h. Porphyritic;* if there are roundish concretions of any mineral, it is called *i. Amygdaloidal;* while it is *j. Vesicular,* if there are open cavities; *k. Variolitic* ("In the principal mass round concretions occur of a compact or radial-fibrous, or concentric felsite (labradorite)" —*Cotta*); and *l. Aphanyte,* or *Compact Diabase.*

E. GABBRO; GRANITONE; DIALLAGE ROCK—"consists of labradorite or saussurite, and diallage, or smaragdite irregularly combined; also sometimes all of these minerals together. It is very coarse-grained, fine-grained to compact, sometimes slaty or spotted."—*Cotta.*

Some Diallage rock, such as that of the Lizard, Cornwall, is a metamorphosed igneous rock.

a. Euphotide.—"A combination of felspar (saussurite) and diallage, with titaniferous and chromic magnetic iron-ore, pyrite, serpentine, and carbonates. The diallage often occurs as the variety smaragdite."—*Cotta.*

b. Noryte, or *Norite* (Scheerer), *Labrador Rock.*—"The Noryte of Scheerer, not of Esmark, is a compound of hypersthene or diallage,

labradorite, orthoclase (containing soda), and even some quartz."—*Cotta.*

Sterry Hunt has described rocks under the name *Anorthosyte.* Of these, some contain a felspar between andesine and anorthite, some between andesine and labradorite; while in others it is a pure labradorite.

Many of these rocks (*a* and *b*), if not all of them, may more properly belong to the metamorphic igneous rocks.

c. Hyperyte, or *Hyperite; Hypersthenyte.*

The hyperyte of Cotta and Dana is a coarse-grained to compact aggregate of labradorite and hypersthene.

Some varieties are said to occur as unaltered igneous rocks, but many of the coarse crystalline varieties would appear to belong to the metamorphic igneous rock series.

F. Dioryte, or Diorite [Gr. *dioros,* a clear distinction, in contradistinction to the doleryte, in which the minerals are indistinct].—A crystalline granular compound of felspar (not orthoclase) and amphibole. Sterry Hunt has called this rock *Anorthyte.*

Many diorytes are undoubtedly metamorphosed igneous rocks. In them the minerals are always prominently and distinctly visible; therefore it does not appear at all improbable that they were the rocks which first received this name. According to Dana, the felspar ought to be *albite.* He however seems to be nearly alone in this opinion.

a. Amphibolyte.—A homogeneous fine-grained compact mass, consisting of labradorite and

amphibole (*Dana*). According to Naumann, the latter ought greatly to predominate.

b. Aphanyte [Gr. *aphanes,* unmanifest], or *Anamesyte* (Jukes).—A compact homogeneous variety of dioryte, without distinct grains.

Some dioryte-aphanytes are said to have as their felspar, orthoclase; in which case they are not, properly speaking, a homogeneous variety of *Dioryte,* but a homogeneous variety of *Syenyte.*

c. Kersanton (Riviere), *Micaceous Dioryte.*—Containing a great and conspicuous quantity of mica.

NOTE.—The highly micaceous diorytes, similarly as the highly micaceous melaphyres and diabases, would be classed by some geologists among the "mica traps."

d. Napoleonyte, or *Orbicular Dioryte.*—A local variety, consisting, according to Delesse, of a combination of anorthite, blackish-green amphibole, with some quartz. The anorthite and amphibole form orbicular concentric layers round a kernel, each mineral forming different layers of alternate light and dark colour.

G. SYENYTE, SYENITE.—A crystalline aggregate of orthoclase and amphibole, with or without quartz. The quartz appears to be more an accessory than an essential.

NOTE. — Some syenytes are undoubtedly metamorphosed igneous rocks, while others do not appear to have had such an origin.

The name Syenyte has been given to various rocks. Haughton, Forbes, Cotta, Werner, and others describe it as a rock in which quartz is not a necessary ingredient; while Jukes, Dana, and

others define it as an aggregate of orthoclase, amphibole, and quartz. Some authorities erroneously class the hornblendic granites among the syenytes. Cotta says: "The orthoclase or microcline is usually the principal ingredient, and being in general red, it gives that colour to the whole rock. There are, however, syenytes whose orthoclase is nearly white." In the syenytes of West Galway, Ireland, of metamorphic origin, the orthoclase is usually white.

Varieties of Syenyte are,—*a*. *Quartzose*, and *b*. *Titanitic*.

Whinstones, or *Greenstones, supposed to be metamorphosed.*

H. Hornblende Rock (Macculloch). — An aggregate of amphibole, felspar (usually not orthoclase), pyrite or marcasite, epidote, &c. &c. Some are so finely crystalline as to be nearly compact, while others contain crystals of amphibole, from one to four or five inches long.

Hornblende rock may in places be schistose, or nodular, or concretionary. Some of the schistose portions of this kind of rock, from Iarconnaught, Ireland, have been proved by Forbes to be derivate rocks; consequently such portions must be metamorphosed tuff. When Hornblende rock is nodular or concretionary, it may have spheroids from the size of a man's head to four or five feet in diameter, irregularly heaped up together, with the interstices filled with a schistose-looking stuff, that has a foliation rudely curling round the nodules; or the interstices may be occupied by a felsitic rock, or even with quartzitic stuff, or perhaps with two or more of these substances mixed together.

Spheroidal or concretionary structure occurs in some whinstones, and Scrope calls particular attention to it, in some of the augytes of Central France. To such a structure in the original (unmetamorphosed) rock, some of that in the Hornblende rock may possibly be due; nevertheless, the greater portion is probably due to the broken-up parts of the flow [the *Friction-breccia* of Cotta] that were rounded by attrition against one another; while the interstices were filled with the abraded or disintegrated portions of the rock, or by foreign matter washed into them by the water into which the flow was poured. This suggestion appears probable, more especially when the typical rock merges into the nodular variety, and the latter, through agglomerate or conglomerate, into schist and gneiss.

a. Actinolite Rock, or *Glassy Actinolite Rock* (Krantz).
b. Tremolite Rock.

Hyaline acicular crystals of actinolite or tremolite, respectively mixed with a felspar (usually not orthoclase), or numerous nests of crystals may occur in a hornblendic felspathic matrix.

NOTE.—Actinolite and tremolite rocks are liable to merge into ophyte, or one of the allied rocks, as all the magnesian amphiboles seem to have a tendency to change by pseudomorphic action, partly or wholly into ophite, steatite, or such minerals.

c. Hyperyte, or *Hypersthenyte* (see *ante,* page 59).
d. Dioryte (see *ante,* page 59).
e. Syenyte (see *ante,* page 60).
é. Felso-syenyte, or *Felsitic Syenyte,* a variety of syenyte, in which the felspar (orthoclase)

predominates to the nearly total exclusion of the amphibole and other minerals.

f. Mico-hornblende Rock, or *Micaceous Hornblende Rock.*

Black, bronze, or white mica occurs as an essential. The flakes are sometimes of a considerable size, but more often they occur in small pockets or secretions. Usually they are regularly, although not very abundantly, distributed through the mass.

A mico-hornblende rock is easily distinguished, as the mica decomposes more readily than the other constituents, and gives the rocks a pitted aspect, if the mica is in bunches or pockets; while, if it is in large flakes, the weathered surface of the rock has often a somewhat graphic character, caused by the weathering away of the edges of the mica. Other varieties also have mica as an essential, scattered through the mass; these latter are often more or less schistoid.

G. **Rocks due to Pseudomorphic Action, or to Weathering.**—Some of these rocks, as will be evident from their description, belong in part to Order No. II. (*Derivate Rocks*); as, however, they are products of the igneous rocks, it seems expedient to describe them altogether.

A. Ophyte, or Ophite; Serpentine.—A compact rock, dull in fracture, with an unctuous feel. Colour dark green to blackish or brownish, reddish or variegated.

Dana divides massive serpentine into *Precious* and *Common Ophyte*. The first "is of a rich oil-green colour, of pale or dark shades, and translucent even when in thick pieces." The common ophyte is of dark shades of colour, and sub-translucent.

"The former has a hardness of from 2·5 to 3; and the latter often of 4 or beyond, owing to impurities."

Ophyte may originally have been either whinstone or felstone. It weathers into an impure ferruginous *meerschaum* of a dirty yellowish colour, giving the rock a peculiar burnt or baked aspect.

A variety is *Ophi-hornblende rock*, or a hornblende rock in which part of the felspar or part of the amphibole is changed into ophyte.

B. Steatyte, *Soap-stone.*—An unctuous, soft, fissile, but, at the same time, tough rock, of a light greenish, greyish, or bluish colour.

Ophyte and *steatyte* often occur together in intrusive masses or dykes, associated with steatitic felstone or ophi-hornblende rock, also with hornblende schist or felsitic schist. Friable felstone, felstone tuff, whinstone tuff, &c., may change into steatyte.

Varieties are,—*a. Felspathic; b. Pyroxenic;* and *c. Amphibolic.*

Steatyte, as formed from felstone or whinstone, may contain a large percentage of felspathic tuff, or of pyroxene or amphibole.

C. Eklogyte, or Eklogite.—An aggregate of green smaragdite and red garnets. The smaragdite forms a finely crystalline matrix, in which the crystals of garnet are disseminated. It is often micaceous. Some varieties undoubtedly are pseudomorphs of hornblende rock.

Note.—Some of the fissile rocks, usually called Eklogyte, are metamorphic sedimentary rocks, and their description is given under the head of *Smaragdite Schist* (see page 93). The rock here described is an intrusive rock.

D. Epidosyte, Epidote Rock. — An aggregate of felspar, amphibole, epidote, pyrite, or marcasite, &c. It occurs as dykes and intrusive masses, or as nodules and lentils in the metamorphic rocks.

E. Kaolin, *Porcelain Clay* [Chinese, *Kau-ling*, high ridge, the name of the place where the clay was first manufactured].—A white, greyish-white, yellowish, sometimes brownish, bluish, or reddish, clay-like or mealy or compact substance, due to the decomposition of a very felsitic rock.

Baron Von Richthofen has proved that kaolin was originally manufactured by the Chinese from *Petrosilex;* but though the name at first indicated an artificial felsitic clay, now the term has generally been adopted for a clay due to the decomposition of a felsitic rock. *Kaolin* sometimes occurs in dykes, but more often it seems to have a bedded structure, when it more properly belongs to the second order of rocks (*Derivate rocks*).

F. Fuller's Earth. — "A substance resembling clay, somewhat greasy, but not in the smallest degree plastic, but falling to pieces in water; usually of a yellowish-green colour; is probably a product of the decomposition of basic igneous rocks."—*Cotta.*

Fuller's Earth sometimes occurs in dykes, at other times, similarly to kaolin, it seems to belong to the *Derivate rocks.*

G. Meerschaum, Sepiolyte. — Compact, with a smooth feel, and fine earthy texture. Colour greyish-white, or with a faint yellowish or

reddish tinge; opaque. An earthy hydrated silicate of magnesia.

NOTE.—*Ophyte* weathers into an impure meerschaum. Dana points out that sepiolyte, in Asia Minor, occurs "in masses in stratified earthy or alluvial deposits;" and Cotta states it "forms separate beds, which are the result of a process of transmutation, probably of magnesite."

H. MAGNESYTE.—An aggregate of the carbonates of magnesia and iron. It may contain felspar, mica, quartz, chrome, nickel, &c.

H. **Tuff.** Ingenite in part, derivate in part [Ital. *tufo*, Gr. *tophos*].—The mechanical accompaniments of the Plutonic rocks, consisting of the dust, powder, cinders, fragments, blocks, and other rock *débris* ejected during an igneous eruption. Subsequently these were more or less stratified by water or air, and afterwards consolidated by pressure, heat, or cement; or, perhaps, by two or more combined.

NOTE.—The name tuff was originally applied to the mechanical accompaniments ejected during an igneous eruption, but afterwards it was erroneously used for any porous vesicular stone, often a purely sedimentary rock, while the term ash was used to denote the true tuffs. Ash, however, is an objectionable name, as an ash is the residue of any substance left after that substance has been burnt; while tuffs are never a pure ash, although portions of ash may form minor constituents. *Tuff* may be used as the name for the mechanical accompaniments of the Plutonic rocks, and *tufa* for those of the Volcanic rocks (*see* page 75).

Correctly speaking, no rock should be called a *tuff* unless the materials forming it were ejected in fragments from an igneous vent, and subsequently fell either on land or in water. In practice, however, this distinction cannot always be followed, as many *tuffose sandstones* or *tuffose shales*, whose

origin is mainly due to the abrasion and disintegration of ingenite rocks, are undistinguishable in aspect or composition from true *tuff*. Forbes has pointed out, that when outbursts of ingenite rock are forced or have flowed into the sea, they may be "at once broken up into a state of division, more or less fine, in proportion to the greater or lesser cooling power of the water mass in immediate contact, and may be spread out into beds by the action of the waves." Many rocks thus formed, although not true tuffs, are yet not only undistinguishable from them, but in some cases (except under the microscope), are also undistinguishable in aspect and composition from igneous rocks. Tuffs may be stratified or unstratified; sometimes they even occur in dykes and pipes. As they, in part, are sedimentary rocks, fossils may occur in them.

Varieties due to Composition.

A. Felstone Tuff, Felsyte or Felsitic Tuff.—An aggregate of felspathic or felsitic parts usually more or less flaky or mealy; colour reddish, greenish, greyish, or bluish, weathering yellowish-white. Often very greasy to the touch, which appears to be due to particles or portions changing into *steatite*.

As previously mentioned, portions of some felstones are very flaky or mealy in aspect; these it is difficult, except when studied *in situ*, to distinguish from felsyte tuff.

Varieties are, — *a*. *Quartzose*; *b*. *Calcareous*; *c*. *Pyritous*; *d*. *Cupriferous*; and *e*. *Hematitic*.

B. Whinstone Tuff, *Basic* or *Greenstone Tuff*.—A greenish, reddish, purplish, or greyish-bluish

rock, from coarse to fine and compact; often laminated, sometimes finely, at other times having alternate layers of fine and coarse materials; they may be conglomeritic or brecciated, when they often merge into *Agglomerate.*

Varieties are, — *a. Hornblendic; b. Pyroxenic; c. Chloritic; d. Calcareous; e. Pyritous; f. Cupriferous;* and *g. Hematitic.*

C. Calcareous Tuff.—Tuff cemented together by a limy or calcareous matrix.

D. Arenaceous Tuff. *E.* Argillous Tuff.—These respectively contain a large percentage of sand and clay. Many of these rocks probably are not true tuff, but are due to the disintegration of igneous rocks, the detritus being mixed with sand or mud. Some arenaceous tuffs are cemented together by a siliceous paste.

F. Hematitic or Ferruginous Tuff. — A reddish or yellowish ferruginous rock; sometimes argillous, at other times arenaceous. It may merge into an earthy limonite.

Note.—Some varieties of the Indian rock called *Lateryte,* from Kutch, seem to be a variety of hematitic tuff. Very similar rocks are found associated with doleryte in Antrim, Ireland: both in Ireland and Kutch the rock may be steatitic.

G. Pyritous Tuff. *H.* Cupriferous Tuff. — Containing a large percentage of pyrite, marcasite, or chalcopyrite, so as to give a character to the rock.

I. Steatitic Tuff.—A greenish, greyish, bluish, or reddish mealy or flaky rock; having a greasy feel. It appears to be a pseudomorph.

Varieties due to Structure.

J. Porphyritic Tuff.

K. Nodular, with its varieties, *a. Concretionary,* and *b. Spheroidal.*

L. Shaly Tuff.—Fine-grained, compact, and deposited in thin laminæ or layers. There are two varieties,—*a. Flaggy,* when the layers are between half an inch and four inches thick, the rock easily splitting into tabular masses; and *b. Slaty,* when there is a well-developed slaty cleavage.

M. Conglomeritic Tuff, Plutonic Conglomerate.—Tuff containing blocks and fragments of different kinds of rock.

Its varieties are,—*a. Brecciated Tuff,* or *Plutonic Breccia,* and *b. Plutonic Agglomerate.*

Variety *a* includes those rocks that contain angular blocks and fragments, while Lyell has introduced the term *Agglomerate* to designate those large irregular unstratified accumulations of blocks and detritus thrown up by igneous eruptions.

Class III.—VOLCANIC ROCKS.

The name of the class is derived from *Vulcanus,* the god of fire. They are eruptive or intrusive rocks, brought up by vulcanicity, and consolidated near or at the present surface of the globe. They are necessarily accompanied by tufa and such mechanically derived associates.

Note.—None of the rocks allied to the volcanic have been placed among the granitic rocks; nevertheless, it appears highly

probable that some varieties of *Liparyte* (Trachyte porphyry) ought to be classed among the *Elvanytes*. Cotta says of the liparytes, which are granitoid in aspect, that in some cases it is impossible to distinguish between them and *Quartz-porphyry* (Elvanyte). "In these cases the only real difference consists in their geological connection with genuine trachytes or their petrographical transition into perlyte or pumice-stone."

I. **Trachytic group.**—Compact or granular, or splintery or cellular, crystalline felsitic or felspathic rock: some contain crystals of quartz, mica, and amphibole, or even pyroxene; the whole either confusedly united or imbedded in a felspathic paste. Some are porphyritic or even granitoid.

The Trachyte group embraces all the siliceo-felspathic volcanic rocks. Among them are also included such transitional basic felspathic volcanic rocks as the *Greystones* of Scrope, the *Trachydolerytes* of Abich, or the *Hybrid rocks of* Durocher.

A. Rhyolyte, or Rhyolite.—"A compact enamel-like, or vitreous matrix enclosing grains or crystals of sanidine" (*rhyacolite*), "oligoclase, mica, or even quartz."—*Cotta.*

In Rhyolyte free quartz appears much more frequently than in common Trachyte; while it contains no amphibole or pyroxene, or at least, those minerals are rarely found in it. From this it is apparent that Rhyolyte is highly siliceous or felsitic Trachyte.

a. Liparyte, or *Liparite; Trachyte-porphyry.*—"Is the name given to those rocks (prevalently felsitic and porphyritic with a compact matrix) which are geologically allied to the trachytes."—*Cotta.*

Liparyte has a compact felspathic matrix, containing crystals of felspar, and sometimes also

mica or quartz. As a rule it is much richer in silica than the trachytes hereafter described. Cotta says it only very rarely and exceptionally contains some traces of amphibole. In some the matrix is compact and somewhat shining; in others it is enamel-like, while in others it is dull. They may be platy or vesicular or pumiceous. Usually light-coloured; some are granitoid and undistinguishable except in their geological position and age from Elvanyte; the latter variety ought probably to be classed among the *Granitic rocks*. As among the Plutonic rocks, so also among the Volcanic rocks, there must be passage-rocks into true granite; among the Volcanic, however, these cannot be so prevalent as among the Plutonic, as the latter rocks have been usually exposed by the force of denudation, while rarely do we find the roots of the more recent eruptions exposed.

b. Perlyte, or *Perlite, Pearlstone, Pearlstone-porphyry*.—"An enamel-like matrix containing round grains, several of which are constructed with concentric layers."—*Cotta*.

Perlyte may be granular, or sphærulitic (with compact or radial striped felsyte balls), or porphyritic, or pumiceous, or vitreous (with resinous lustre), or argillaceous.

c. Obsidian (so named after its discoverer, the Roman named *Obsidianus*).—Trachytic or volcanic glass.

Obsidian may be compact, or a mere glass, or porphyritic, with sanidine crystals, and sometimes also mica plates, or sphærulitic, in which case it is a passage-rock into perlyte.

d. Pumice, Vesicular Obsidian (Ital. *pomice*, akin

to *spuma*, froth).—Vesicular volcanic glass. Some varieties are so porous that they will float on water.

e. Phonolyte or *Phonolite Clinkstone* (Gr. *phonè*, sound, and *lithos*, stone). — Compact, in places vitreous; due to cleavage-surfaces of felspar; usually dark greenish-grey. Often platy in texture, and rings when struck with a hammer. Weathers with a whitish crust, similarly to many of the *felstones*.

Phonolyte may be compact, vesicular, flaky, variolotic, porphyritic, or amygdaloidal.

B. Trachyte (Gr. *trachys*, rough).—"A compound of sanidine, oligoclase (or even albite and labradorite), with some amphibole or pyroxene, and dark-coloured mica. A rough principal mass in which, as matrix, some of its mineral constituents are frequently distinctly and separately developed and imbedded."—*Cotta*.

Varieties in Composition.

a. Sanidine Trachyte.—An aggregate of sanidine crystals, with some amphibole or mica. From coarse to fine, and from porphyritic to compact.

b. Drachenfels Trachyte.—Containing oligoclase in addition to the sanidine, with some magnesia-mica, and amphibole, also pyroxene, magnetite, and titanite.

c. Domyte, or *Domite* (after *Puy de Dôme*, Auvergne). — Oligoclase trachyte, having no sanidine. It also contains some amphibole or pyroxene, and dark-coloured mica.

d. Andesyte, or *Andesite* (after the *Andes*).—Fine

or compact trachyte, sometimes vitreous; dark colour, with imbedded crystals.

e. Trachydoleryte, or *Trachydolerite*; *Greystone*.—"A compound of oligoclase (or labradorite) with amphibole or pyroxene, some magnetite, and frequently also mica. These minerals lie imbedded in a grey or brown matrix."—*Cotta*.

Trachydoleryte is the passage-rock between the Trachytes and Augytes.

Varieties in Texture.

f. Granular Trachyte; g. Compact; h. Porphyry; i. Trachyte-lava or *Vesicular Trachyte;* and *j. Alum-stone.*

The last does not appear to be a normal rock, but to be due to decomposition.

J. **Augitic Group.**—Aggregates of felspar with pyroxene and amphibole; they frequently contain mica and magnetite, while quartz is rarely present.

The Augitic group includes all the basic volcanic rocks; they may be compact, crystalline, granular, porphyritic, amygdaloidal, vesicular, or variolitic.

A. Augyte or Augite, Doleryte or Dolerite, Basalt.—A crystalline granular aggregate of labradorite or nepheline and pyroxene, with some titaniferous magnetite; usually blackish or dark-coloured. In the compact mass there often occur prominently distinct grains or even crystals of olivine, labradorite, pyroxene, and magnetite.

Note.—The name *Basalt* is given above, as it is in such common use; it ought, however, to be solely confined to the compact varieties. *See* Doleryte among the Plutonic rocks.

Varieties in Composition.

a. Nephelite Augyte, when this mineral is the felspar.

b. Hauynophyre (Rammelsberg); hauyne being in the place of labradorite.

c. Allogovyte, or *Allogovite* (Winkler), a reddish variety of labradoritic augyte; and

d. Common Augyte, Labradoritic Augyte.

Varieties in Texture.

e. Anamesyte, or *Anamesite* (Leonhard).

f. Basalt, or *Compact Augyte.*

e and *f* seem to be different names for the same kind of rock, as both refer to those augytes that are so fine-grained and compact that the constituents are undistinguishable.

g. Porphyritic, containing felspar crystals.

h. Amygdaloidal, having almond-shaped concretions.

i. Basalt Lava, or *Vesicular Augyte,* being scoriaceous or full of minute holes; and

j. Variolitic, when there are dark grains in a lighter-coloured mass.

h and *i* always merge one into the other, as the latter was the original condition of all amygdaloids.

B. Leucityte, or Leucitite, Leucite-rock. — A more or less distinct aggregate of leucite and pyroxene, with some magnetite.

Varieties are,—*a. Compact; b. Leucitophyre,* or *Porphyritic,* having felspar crystals; *c. Amygdaloidal;* and *d. Leucityte Lava,* or *Scorious* or *Vesicular Leucityte.*

K. **Volcanic Tufa** and **Peperino** (Ingenite in part, Derivate in part).—According to Scrope, the Italian geologists restrict the term *tufa* to the felspathic or trachyte aggregates, which are grey or whitish; while the name *peperino* denotes the augitic varieties, which usually are brownish.

A. Tufa. — A trachytic aggregate of slag, ash, pieces of pumice and lava, with fragments of various other rocks. It may be arenaceous, argillaceous, conglomeritic, or brecciated. The principal fragments and particles are of trachyte.

Varieties are,—*a. Trachyte Tufa; b. Pumiceous Tufa* or *Pumiceous Sand,* which have received the following local names: *Trass* (Rhine), *Tosca* (Sicily), and *Pausilippo Tufa* (Teneriffe); *c. Phonolyte;* and *d. Pozzuolana,* a volcanic sand, very useful in the construction of mortar for hydraulic works.

B. Peperino.—A light porous rock; augitic sand, scoria, cinders, &c., cemented together, the grains having a peppercorn-like appearance.

Varieties are,—*a. Augyte Peperino; b. Leucityte;* and *c. Palagonyte,* called after Palagonia, in Sicily.

C. Volcanic Conglomerate, with its varieties, *a. Volcanic Breccia,* and *b. Volcanic Agglomerate.* Some of the mechanical accompaniments of the volcanic rocks consist of more or less stratified accumulations of blocks and fragments of volcanic and other rocks, usually more or less loose, but sometimes cemented together. If the contained blocks are round or roundish, the rock may be called *Volcanic*

Conglomerate; if they are more or less angular, a *Volcanic Breccia;* while if the accumulation is massive and without stratification, Lyell's name of *Volcanic Agglomerate* may be adopted.

Class IV.—TRANSITION OR METAMORPHIC SEDIMENTARY ROCKS.

THESE rocks, similarly to the metamorphosed igneous rocks, may occur in various degrees of change, from a rock scarcely altered to a rock undistinguishable from granite, in accordance with the intensity of the metamorphic action to which they were subjected.

The lowest degree of metamorphism seems to be, principally, induration, with the planes of the most conspicuous structure (whether lamination, cleavage, or jointing) glazed or micacized, while, at the same time, peculiar structures are developed. In finely laminated, or cleaved rocks, a crumpling takes place; in others a nodular or concretionary development; in some the joint-lines and the rock in their immediate vicinity, are silicified or hardened, so that on the weathered surfaces of the rocks are formed well-marked rectangular, rhombic, or oblique depressions. In the second degree, the rocks become typical schist; in the third gneiss; while in the fourth they become granitoid, and from that pass into typical granite.

Rocks usually pass in this order to the highest degree of change; however there are exceptions, as some rocks are more susceptible of change than others, on account of their mineral constituents.

Thus some sandstones, or even shales that contain the constituents of gneiss, may have a gneissoid aspect, while the associated rocks have only been changed into schist.

NOTE.—The following changes in sedimentary rocks were observed in co. Mayo, Ireland :—*Felspathic* and *micaceous sandstones*, changing into mica-schist and gneiss. This gneiss, however, was not typical ; that is, the quartz, mica, and felspar were not arranged in leaves ; nevertheless the rocks contained these three ingredients, and had an incipient foliation ;—*quartzose sandstones* and *grits*, changing through quartz-schist, or quartzitic mica-schist into gneiss ; *green tuffose shale* and *slate*, through hornblende schist, chlorite schist, or talc schist into basic gneiss ; *argillaceous shale* and *slate*, through argillyte into mica-schist or chloritic mica-schist, and from that into gneiss ; *felstone* or *felsitic tuff*, through felsitic schist into steatitic schist, garnetiferous schist, or talcose schist.

L. **Gneiss.**—When typical, a crystalline granular aggregate of quartz, felspar, and mica ; occurring in leaves or plates, more or less parallel to one another. Typical gneiss is rather uncommon, as usually various other minerals besides the quartz, felspar, and mica occur, disarranging the regularity of the leaves.

Varieties in Composition.

A. FELSPATHIC and FELSITIC GNEISS, having one or more felspars as the predominant ingredients.

These may be divided into,—*a. Orthoclase, b. Oligoclase, c. Alpinyte* (Simler), and *d. Adularia-gneiss.*—Cotta.

c. is named after the *Alps*. It is principally made up of a variety of oligoclase, and is a gneissoid aggregate of quartz, oligoclase, and an undetermined flaky green mineral. The latter Cotta suggests "probably belonging to the mica species."

A variety of felspathic gneiss, having adularia in the place of orthoclase, is mentioned by Cotta.

Felspathic gneiss is the passage-rock between gneiss and felsyte schist.

B. Micaceous Gneiss, containing much mica.

Its varieties are,—*a. Two-mica Gneiss, b. White Mica Gneiss, c. Black Mica Gneiss.*

Varieties might also be named after the different kinds of mica.

Micaceous gneiss is the passage-rock between gneiss and *mica-schist.*

C. Quartzitic Gneiss. — This is the passage-rock between gneiss and *quartz-schist*, or *quartzyte.*

D. Basic Gneiss has numerous varieties, according to the most prevailing accessory, or the mineral that gives character to the rock mass. The most particular are, *a. Hornblendic* or *Amphibolic; b. Chloritic* or *Ripidolitic; c. Talcose,* and *d. Protogene Gneiss,* when talc replaces the whole of the mica.

Note.—It is said by King (India), that to a gneissoid rock, composed of quartz, felspar, and talc, the name Protogene was first given, and not to an intrusive rock. Hornblendic gneiss is sometimes erroneously and unscientifically called syenitic gneiss, while chloritic gneiss and talcose gneiss have absurdly by some been classed together under the name of Protogene gneiss. (See *note on the Hornblendic Granite*, page 33.)

E. Iolitic Gneiss, *F.* Hematitic Gneiss, and *G.* Graphitic Gneiss, may be thus named respectively, if iolite, micaceous iron-ore, or graphite replace most of, or the whole of the mica.

Structural Varieties.

H. Common or Grey Gneiss may be divided into,—*a. Compact Gneiss, b. Slate-gneiss, c. Ribaned*

or *Lagen Gneiss*, and *d. Fibrous* or *Stangel Gneiss*.

Compact gneiss is usually a more or less indurated grit, or in some cases it may be a slightly altered *bedded* felstone. In *Slate gneiss* there is a distinct slaty cleavage in a fissile mass of small even-grained particles, the mica being seen on the cleavage-planes alone. *Ribaned gneiss* is when the constituents occur in thin layers, and form a riban; while in *Fibrous*, or *Stangel gneiss*, the ingredients are placed "in a fibrous manner towards one direction; so that a peculiar linear parallel conformation is produced." In a variety of fibrous gneiss the quartz particles are of an elongated almond-shape, and a cross section of the rock has a peculiar aspect.

I. Oblique Gneiss, having as varieties,—*a. Curled Gneiss, b. Nodular Gneiss*, and *c. Conglomeritic Gneiss*.

The straight linear arrangement of the leaves of the constituents may be deflected by various causes; in some by oblique lamination, or by cleavage in the original rock; in others by a crumpled foliation, or spheroidal structure; also by the original lamination curling round contained nodules or blocks, if the rock before alteration was nodular or conglomeritic.

In ordinary gneiss, the direction of the foliation seems to be due to structure in the original rock; while in granitoid gneiss, it nearly always is linear, parallel, and regular, apparently being a more or less introduced structure. Conglomeritic, and some nodular rocks, appear capable of resisting this new arrangement longest, for in many rocks of these kinds, even when very granitoid, the foliation will

remain deflected or curled in the immediate vicinity of inclosed blocks or nodules; while in some granites regular or irregular masses, differently constituted to the rest of the rock, will occur.

In West Galway, Ireland, conglomeritic gneiss is usually associated with metamorphosed igneous rocks, and probably is metamorphosed conglomeritic tuff, or agglomerate.

J. Porphyritic Gneiss; *K.* Granitoid Gneiss.—These subgroups are allied, nearly all porphyritic gneiss being also granitoid.

Gneiss may have large and prominent crystals of felspar disseminated through the mass. This usually occurs in the granitoid subgroup, but not always. In some granitoid gneiss there is a distinct foliation, while in others it is indistinct.

The degree of distinctness of the foliation of the granitoid gneiss appears due to the intensity of the metamorphic action to which it was exposed. Granitoid gneiss is the passage-rock between gneiss and granite.*

M. **Schist** [Gr. *schistos,* split or divided].—A crystalline fissile aggregate, consisting, when typical, of two well-developed minerals, occurring in thin plates or leaves. Mica is usually one of these minerals; however, various others also occur, sometimes as accessories, but locally as essentials, thereby forming different subgroups and vari-

* Hereafter microscopists may prove that granitoid gneiss ought more properly to be classed with the Granitic rocks (Class No. 1), and taken out from the Transition rocks (Class No. 4), as in it the original structure is obliterated, except in a few rare exceptions. The mineral constituents seem to be altogether crystalline, no felsitic or felspathic tuff occurring in granitoid gneiss.

eties. When mica is absent, quartz is nearly always present.

Schist is easily separated along its foliation-planes, while across them it is tough, and breaks with from an uneven to a hackly fracture.

A. ARGILLYTE, or ARGILLITE, *Argillous* or *Clay Schist.*—A fissile more or less indurated argillous rock, having the planes of the most conspicuous structure in the original rock, glazed, mineralized, or micacized. Certain minerals, as chiastolite, phyllite, pyrite and such like, are developed in some, and peculiar structures in others; thus forming varieties.

Varieties in Composition.

a. Chiastolitic Schist.
b. Phyllitic Schist, or *Ottrelitic Schist.*
c. Carbonaceous Schist.
d. Alum-schist.
e. Spilyte or *Spilite,* or *Calcareous Schist,* and
f. Dolomitic Schist.

Chiastolitic schists are mostly argillous rocks; nevertheless some are micaceous. The crystals are usually disseminated through the mass quite irregularly, but in some varieties they are stellated, usually on the surfaces of the original structure of the rock. *Phyllitic schist* contains laminæ of phyllite (*Ottrelite*). *Carbonaceous schist* is rich in carbon, and often is pyritous; of it *Alum-schist* seems to be a variety, being due to the decomposition of pyrite in pyrito-carbonaceous schist. *Spilyte* and *Dolomitic schist* are passage-rocks into schistose limestone and schistose dolomyte.

Structural Varieties.

g. Folded or *frilled Argillyte, h. Contorted,* and *i. Fibrous.*

Variety *g* has a folding or crumpling that gives it a frilled aspect: this peculiar folding is only found in some of the schists, and evidently is solely due to the metamorphic action, as it does not follow any structure in the original rocks. In variety *i* the particles are so linear and parallel-arranged as to give the rock a woody aspect, a weathered block looking like the butt of a sallow or some such tree.

Argillite is the passage-rock between normal clay-slate, or shale, and mica-schist. It occurs in various stages of metamorphism. Sometimes the whole mass appears homogeneous, differing only from clay-slate, or shale, by its superior lustre; nevertheless it is rarely without traits, more or less characteristic, of mica-schist; such as the crumpling, crushing, folding, twisting or contortion of the laminæ; also the hardening of the joint and other lines, with the development of minerals, especially on the surfaces of beds or on the lamination and cleavage-planes.

B. QUARTZYTE, or QUARTZITE, *Quartz-schist.*—Chiefly consists of quartz with some mica; the latter being most conspicuous on the planes of foliation.

Varieties in Composition.

a. Itacolumyte (Eschwege), *Pedra elastica* (Anchieta), *Micaceous Quartzyte.*—"A fine-grained and at the same time schistose compound of

quartz with some mica, talc, or chlorite."—*Cotta.* Henwood says of the Itacolumyte of Minas Gerais, "quartzose talco-micaceous slate."

These flexible quartzytes were first noted among the metamorphic sedimentary rocks of Brazil, and were named after Itacolumi Peak. Burton says there are three different kinds of rock named after this peak: 1st, the flexible quartzyte, or *Pedra elastica,* under which name it was described nearly three centuries ago by Padre Anchieta; 2nd, *Diamantine itacolumyte,* the matrix of the diamond, "a hard talcose rock of distinctly laminated quartz, white, red, or yellow, granular, with finely-disseminated points of mica;" and 3rd, in Minas the name is applied to "refractory sandstone grits, a fine crystalline rock evidently affected by intense heat." The peak itself consists of none of the three kinds, although all are called after it.

Jukes thus describes Itacolumyte:—"A genuine unaltered sandstone, more or less micaceous, like other sandstones, but the mica in worn spangles, not in connected flakes." The rock, of which this is a description, came from India. In it are lines that appear due to deposition; when placed under the microscope, it is found to be full of long drusy cavities, which lie in lines rudely parallel with the structure of the rock. The cavities open and shut when the slab is bent. According to Dana, Itacolumyte pertains to the talcose series, and is the matrix of the diamond; this evidently is Burton's second kind of rock.

b. Itabiryte (Eschwege), *Jacotinga.*—Ferruginous quartz-schist, a variety of Itacolumyte, named after Itabira, in Brazil. Eschwege,

who first described the rock, makes it the matrix of the diamond. Some very ferriferous varieties are said to be worked in Brazil as iron-ores; they are more or less auriferous. Itabiryte, Dana says, "contains much specular iron-ore in grains or scales, or in the micaceous form." *Jacotinga* Henwood describes as an "auriferous micaceous iron-schist."

c. Felsitic Quartzyte—An aggregate of quartz and felsite, sometimes also felspar and a little mica; usually more or less massive, rarely well foliated.

Structural Varieties.

d. Quartz Rock (Jukes), *Granular Quartzyte.*
e. Fibrous Quartzyte, and
f. Conglomeritic Quartzyte.

Variety *d* is fine-grained, homogeneous, and more or less saccharoid in aspect, often merging into felsitic quartzyte (*c*). *e.* has an arrangement in long rude prisms like coarse wood; while *f.* contains pebbles, usually ovate, but sometimes more or less angular; this is evidently a metamorphosed conglomerate, the normal form of the pebbles having been elongated by the subsequent metamorphic action.

Quartzyte or Quartz-schist (*B*) is an undoubted metamorphic sedimentary rock, originally a highly siliceous sandstone or grit. There are, however rocks described as Quartzyte or Quartz-rock that seem not to be metamorphic rocks, but rather normal rocks, either deposited from a solution, or perhaps a variety of intrusive rock. Some of these

quartz-rocks appear to occur as masses in unaltered rocks.

Felsitic quartzyte is a remarkable variety; some would seem to be metamorphosed *Petrosilex;* while others merge into quartz-rock on the one hand, and into Felsitic granite or Felsite-rock on the other. Some also occur in bedded masses, when they may possibly be metamorphosed felspathic sandstones.

C. Felsyte Schist.—A felsitic fissile rock; colour whitish, greyish, or greenish; from compact to mealy or granular in texture.

Note.—Some of the compact varieties of Felsyte schist are identical with rocks named by Krantz as *Leptinyte* or *Whitestone;* on the other hand, Cotta classes *Leptinyte* with *Granulyte,* apparently considering both as intrusive rocks.

Varieties in Composition.

a. Micaceous, b. Quartzose, and *c. Pyritous.*

Varieties in Structure.

d. Ribaned, when the mineral constituents are in layers or seams, alternating with one another.

e. Mealy, having a leafy or scaly structure; and

f. Gneissoid or *granular,* a granular felsitic rock, slightly fissile, with grains of quartz disseminated through the mass, also a little mica.

Note.—Gneissoid or granular felsyte schist merges into felsitic quartzyte. In some localities it is an undoubted bedded or interstratified rock, while in others it is evidently intrusive. Perhaps in the first case it may be a metamorphosed stratified felstone or tuff (which could only be determined by a microscopical examination), while in the latter it may be a metamorphosed intrusive felstone. The latter variety of granular felsyte schist appears to answer the description of the rock called granulyte by Cotta.

D. Mica-schist.—When typical, a foliated or fissile aggregate of quartz and mica. Usually the foliation is regular; nevertheless it may be crumpled, crushed, folded, twisted, contorted, curled, nodular, or spheroidal.

Varieties in Composition.

a. Two-mica Schist, b. Chloritic, c. Talcose, d. Garnetiferous, e. Chiastolitic, f. Andalusitic, g. Amphibolic, h. Epidotic, i. Quartzose, j. Felsitic, k. Calcareous, l. Schorlaceous, m. Pyritous, n. Pyrrhotitic, o. Hematitic, and *p. Graphitic.*

The varieties in composition are named after conspicuous minerals, locally essentials. Most of these rocks, however, are only passage-rocks into the other subgroups of schist; some even (such as *Epidotic mica-schist*) are not normal rocks, but due to a secondary change in the mineral constituents.

Structural Varieties.

q. Fine Mica-schist, where all the ingredients are small and even-grained.
r. Ribaned, with the minerals in layers or bands.
s. Fibrous, with a woodlike arrangement.
t. Nummoid, having in it small discs of quartz, giving the rock an appearance as if studded over with pieces of small coin.
u. Wavy.
v. Frilled, having the foliation folded or crumpled on itself.
w. Curled or *Spheroidal.*
x. Knotty or *Concretionary.*
y. Nodular; and
z. Gneissoid; the last-named variety being the passage-rock between mica-schist and gneiss.

E. Basic Schists.—Schist in which such minerals as amphibole, ripidolite, talc, and the like, replace the whole, or nearly the whole, of the mica, and become essentials of the rock.

Varieties are,—*a. Hornblende,* or *Amphibole Schist; b. Actinolite Schist; c. Chlorite* or *Ripidolite Schist; d. Chloritoid Schist* (Hunt); *e. Potstone; f. Talc Schist; g. Garnet Schist; h. Tourmaline,* or *Schorl Schist;* and *i. Rhætizitic* or *Magnesia Schist.*

It is evident that with more mica, any of these rocks may pass into one of the varieties of mica-schist; or that one of the varieties of mica-schist, by a loss of its mica, may pass into one of the basic schists. Sterry Hunt describes a dark-coloured Canadian subvariety of chlorite-schist as largely composed of chloritoid, a mineral allied to ripidolite and phyllite; and Cotta describes potstone as a felt-like web of ripidolite, and rarely foliated. Perhaps these two varieties of schist would be more properly classed as varieties of argillyte. Rhætizitic schist is described by Forbes as remarkable for the predominance of silicates of alumina and magnesia, rhætizite, iolite, chiastolite, &c.

The basic schists have numerous structural varieties. They are, however, very similar to those mentioned when describing mica-schist; therefore it is unnecessary to enumerate them here.

F. Metallic Schists.—Schists, in which a mineral ore replaces part or the whole of the mica, and gives a character to the rock mass.

The principal varieties are,—*a. Mico-iron Schist, b. Pyrite Schist,* and *c. Pyrrhotite Schist:* other ores may also give a character to a rock.

G. BURNT SHALE.—Altered argillous rocks, due to the burning of carbonaceous beds.

Varieties are,—*a. Burnt Clay, b. Rock Slag,* and *c. Porcelanyte.*

H. MINERALS FORMING ROCKS.

a. Quartz and *Jasper,* generally in veins.
b. Corundum, in subordinate layers.
c. Apatite, sometimes forms compact spheroidal masses.
d. Magnesite, in subordinate masses.
e. Orthoclase.
f. Pistacite; and
g. Pycnite, generally in veins.
h. Lepidolite, rarely forms independent rocks.
i. Lievrite or *Ilvaite,* in subordinate beds.
j. Magnetite.
k. Anthracite.
l. Graphite.

Normal graphite is pure carbon with a little oxide of iron mechanically mixed. Graphite occurs in beds and imbedded masses, laminæ, or scales, in granite, gneiss, schist, and schistose limestone. Of it Dana says, "It is, in some places, a result of the alteration by heat of the coals of the coal formation."

m. Eisenkiesel, "a concretionary rock, made up of red and brown iron-ore, and fragments of bright red jasper."—*Bauerman.*

n. Garnet Rock.

One variety is massive, of a milk-white colour, very hard and heavy, with a peculiar graining through the mass. Others are brownish or reddish, and more or less crystalline; these usually pass into

a highly crystalline vuggy rock, that has as accessories, pyrite, marcasite, chalcopyrite, epidote, calcite, &c.: occurs in veins and subordinate masses.

N. **Slate** [according to Worcester, originally spelt "Sclate." Old Fr. *esclat*, a splinter, a shingle. Celtic *scorlt*, to split or cleave].—Originally shale or clay, into which a subsequent slaty cleavage has been introduced.

Some slates are said to belong to the Metamorphic series. The slaty structure, however, seems more connected with Sedimentary than with Ingenite rocks. Slates often occur associated with unmetamorphosed sedimentary rocks, and many metamorphic rocks are known to have been cleaved prior to their being metamorphosed. Slates are mentioned here, but they will be described hereafter among the Derivate rocks, as varieties of the subgroup *Argillous rocks* (*see* page 103).

O. **Calcareous Rocks** (Lat. *calx, calcis*, lime).

A. Schistose Limestone.—A crystalline granular or nearly compact aggregate of calcite, with more or less ripidolite, mica, felsite, quartz, pyrite, galenite, &c.; often more or less fissile, sometimes highly schistose; usually the foreign minerals are in more or less regular lines or layers, but in some varieties they are disseminated through the mass of the calcite.

a. Cipollino, or *Micaceous Limestone*.—Rich in mica, which gives the rock a schistose texture; this variety graduates into Spilyte.

b. Calciphyre (Brongniart), or *Garnetiferous Limestone*, containing garnets and pyroxene or felspar.

c. Hemitrene, or *Amphibolic Limestone.* In addition to the amphibole, it generally contains grammatite.

d. Felsitic Limestone.—The felsite often occurs in highly crumpled parallel layers.

e. Statuary Marble, or *Saccharoid Limestone.*—"A white, fine-grained rock, resembling loaf sugar in colour and texture, working freely in any direction, not liable to splinter, slightly translucent, and capable of taking a polish. Flakes of mica or chlorite sometimes exist in it."—*Jukes.*

Typical statuary marble should answer the above description, but the rock in mass is often more or less schistose, and also streaked with dark lines, caused by foreign minerals being associated with the calcite.

f. Granular Schistose Limestone.—A granular crystalline, more or less schistose limestone; containing some mica, ripidolite, felsite, or even quartz. Colour white, pale grey, dove, light blue, greenish, reddish, purplish, or yellowish. It is often impregnated with microscopic crystals of pyrite, marcasite, galenite, or chalcopyrite.

P. **Pseudomorph Calcareous Rocks.**—Most of these rocks are pseudomorph metamorphic rocks; some, however, may be derived direct from the original rocks.

A. Schistose Dolomyte.—A crystalline aggregate of calcite and dolomite, together with some ripidolite, talc, or mica: pyrite, marcasite, or chalcopyrite are usually present in greater or less quantities, but minutely disseminated

through the mass. The rock, though usually schistose, may be sometimes compact or granular; when compact, it breaks with a conchoidal fracture. The colours of these dolomytes are very various: a handsome variety is milk-white. Many of them weather into a micaceous ferriferous sand.

Some varieties are,—*a. Micaceous; b. Pyritous; c. Saccharoid;* and *d. Granular.*

The most marked varieties in composition are those due to an excess of mica, or one of the pyrites; and in structure, the saccharoid and the granular. The latter are somewhat similar in aspect to saccharoid and granular limestone, but harder, although more easily decomposed by meteoric action.

Ophyte and steatyte occur associated with the calcareous rocks, but more especially with dolomyte, they being due to pseudomorphic action. At Lissoughter, Galway, Ireland, blocks of dark green very pure serpentine, coated with a thick crust of rusty yellow impure meerschaum (locally called *Cream*), are found on or close to the surface of the ground; lower down, the solid rock was an ophicalcyte, often micaceous or felsitic; while in depth the ophicalcyte passed into a more or less schistose dolomyte. Dana, Jukes, and others also mention dolomytes which have been noted as graduating into ophytes. It should be borne in mind, that the ophytes and steatytes now to be described are pseudomorph sedimentary rocks, while those previously mentioned (*see* page 63) were pseudomorph igneous rocks.

B. Ophyte [Gr. *ophis*, a serpent], *Serpentine, Verd antique, Ophiolyte* (Dana and Hunt).—When

pure, a compact, dark green aggregate of *serpentine*, usually associated with calcite, dolomite, and magnesite; and with such minerals as talc, ripidolite, magnesian mica, &c.; unctuous to the touch on fresh fractures.

The most common varieties are,—*a. Ophidolomyte; b. Ophimagnesyte; c. Ophicalcyte;* and *d. Ophyte Schist.*

The ophytes have been classed by Hunt: 1st, Dolomitic, 2nd, Magnesitic, or 3rd, Calcitic, according to whichever mineral gives a character to the rock-mass. To these may be added the schistose varieties, as all ophytes of this class become in places schistose, they being impregnated with, or having layers of, mica or some other conspicuous ingredient not necessary to a typical ophyte, but giving a more or less marked schistose character to the rock-mass.

C. STEATYTE, or STEATITE [Gr. *stear, steatos,* fat].—A grey, blue, green, reddish or whitish fissile aggregate of steatite, with some talc, ripidolite, amphibole, or magnesian mica: has a mealy aspect; very unctuous to the touch; cuts easily, but tough.

The principal varieties are,—*a. Felsitic; b. Hornblendic; c. Pyroxenic; d. Micaceous; e. Steatyte Schist* (this class of steatyte always graduates into a schistose rock); *f. Pyrallolyte* (Nordenskiold), greyish to clouded milk white in colour, compact, translucent, steatitic rock. According to Hunt, it is identical in composition with talc.

Pyrallolyte occurs associated with ophyte, but seems to be only a secondary rock filling up

"shrinkage-fissures," or open fault-lines. In Connemara, Ireland, there is a variety having dendrites disseminated through it. It is manufactured into ornaments, and called *Moss Serpentine*.

g. *Onkosin* (Kobell), *Agalmatolyte* (Sterry Hunt).—A greenish or greyish corneoid steatitic rock. It, at first, was taken for ophyte.

D. MAGNESYTE.—An aggregate of carbonate of magnesia and carbonate of iron, but may contain felspar, mica, quartz, chrome, nickel, &c.

E. SMARAGDITE SCHIST.—An unctuous fissile rock, an aggregate of smaragdite and mica, but often containing felsite, quartz, and other foreign substances. One variety is *garnetiferous*, and is similar to, if not identical with, the micaceous eklogyte of some authors. Usually smaragdite schist is associated with ophyte, steatyte, or talc, but sometimes it forms independent beds.

PART III.

Order II.—*DERIVATE ROCKS.*

Class I.—SUBAQUEOUS ROCKS.

THE name of this class of rocks points to their having been deposited either mechanically or chemically in water [Lat. *sub*, under; *aqua*, water]. —The materials of which they are composed have been derived from previously existing rocks that were denuded by marine, meteoric, or glacial abrasion, or by a chemical process.

A. Rocks for the most part mechanically formed.—This group includes all the rocks principally due to mechanical deposition. The detritus from which they were formed varies from an impalpable powder to pieces of considerable size, all being formed by one or more of the denuding forces,—marine action, meteoric abrasion, or glacial action. The first of these forces not only destroys, but it also reconstructs, while the detritus due to meteoric and glacial abrasion, prior to being formed into rocks, have to be transported by wind, "rain, and rivers," or some other carrier, for deposition and rearrangement at the bottom of seas or other waters.

The mechanically-formed subaqueous rocks make two well-marked subgroups; namely, *Arenaceous* or *sandy*, and *Argillaceous* or *clayey*.

A. Arenaceous Rocks [Lat. *arena*, sand].—Consisting for the most part of siliceous or quartzose particles and fragments, sometimes loosely piled together, but often united compactly, in a typical arenaceous rock by a siliceous matrix. Some sandstone varieties of these rocks may have a calcareous, ferruginous, or some other such base.

a. Sand, Gravel, and Shingle.—Of loose accumulations of water-worn fragments Page thus writes: "When the fragments are less than the size of a pea they are called *Sand;* when the pebbles vary from the size of a pea to that of a hen's egg, they are called *Gravel;* and when the fragments are larger, *Shingle.*"

Usually the fragments in *sand, gravel,* or *shingle* are more or less rounded; nevertheless, sometimes they are angular. Sand, gravel, and shingle more generally occur as surface deposits; sometimes, however, they belong to much older formations.

Note.—The basal beds of the Permian system, and in some cases beds in the Carboniferous and Silurian systems, are a *gravel* or *shingle,* while sands are not uncommon in different groups of rocks.

Local Names for Gravel and Shingle.

Rubble, "rough angular gravel, either loose or compacted into stone."—*Jukes. Brash* (English), *Foundation* (Irish), the broken and angular fragments of any rock, lying on, and separating it from, the overlying drift.

b. Conglomerate [Lat. *con,* together, and *glomerare,* to gather].—A fine or coarse matrix

containing numerous round or roundish blocks, pebbles, or fragments of one or more varieties of rocks.

Subvarieties in composition may be called (a.) *Calcareous,* (b.) *Hematitic,* (c.) *Cupriferous,* (d.) *Pyritous,* (e.) *Plumbeous,* (f.) *Shale Conglomerate,* having an indurated clayey or shaly matrix, (g.) *Slate Conglomerate,* where blocks and fragments are inclosed in a well-cleaved or slaty matrix.

In the *Metalliferous Conglomerates,* the matrix for the most part is a metallic ore. They may be *ferriferous,* or containing iron-ore; *cupriferous,* or coppery; and *plumbeous,* or leady. These conglomerates are not uncommon in places in the Lower Carboniferous: some of the plumbeous in the New Red are said to be valuable lead ores.

Special names might also be given to subvarieties from the contained fragments, if the conglomerate only contains pieces of one kind of rock, or the fragments of one kind of rock predominate. Such names, however, would be too numerous to mention.

c. Breccia [Ital., a crumb or fragment].—An agglutination of angular fragments of one or more kinds of rocks.

The subvarieties of Breccia are somewhat similar to those of conglomerate; namely, (a.) *Calcareous,* (b.) *Hematitic,* (c.) *Cupriferous,* (d.) *Pyritous.* There is, however, a peculiar subvariety, (e.) *Shale Breccia,* when in a more or less calcareous base are inclosed pieces of shale.

These inliers do not appear originally to have

been fragments of a shale rock, but rather to have been pieces of clay that were caught up in the calcareous matrix, and subsequently became indurated and shaly.

d. SANDSTONE and GRIT. — Sand consolidated by extreme pressure or by the aid of a cement. When typical the grains are quartzose, but in all of the subvarieties there are admixtures of one or more other substances. If the rock has a distinct granular structure, or is capable of being ground or separated into grains, it is called *Sandstone;* while, if the rock is hard and compact, the grains not being visible to the naked eye, or if the grains of sand are so firmly compressed or cemented together that it is impossible to separate them, then the rock is classed as a *Grit.*

The subvarieties of sandstone and grit are very numerous. In composition they may be—(a.) *Calcareous,* (b.) *Argillous,* (c.) *Felspathic,* (d.) *Micaceous,* (e.) *Hematitic,* (f.) *Cupriferous,* (g.) *Pyritous,* and (h.) *Tuffose.*

The sandstones are more often argillous, felspathic, micaceous, and tuffose, than the grits.

Of structural subvarieties there are—(i.) *Pebbly,* (j.) *Cleaved,* (k.) *Oblique* or *Obliquely foliated,* (l.) *Concretionary,* (m.) *Spheroidal,* (n.) *Nodular,* (o.) *Lenticular;* and of sandstone only (p.) *Friable.*

Sandstones necessarily are oftener oblique, concretionary, spheroidal, nodular, and lenticular, than grits. Friable sandstones have such a weak matrix that the grains separate and the rock easily returns

to its original condition of sand. Many of these have a concretionary or spheroidal structure, and contain hard spheres or concretions; while some compact sandstones inclose spherical masses of friable sandstone, or even sand. A *quartzose* or *hard sandstone,* correctly speaking, is a grit: there are some grits so quartzose as scarcely to be distinguished from *quartzyte.*

e. FLAGSTONE, or FLAGS.—A grit or sandstone which was deposited in layers, from a quarter of an inch to three or four inches in thickness. The rock now splits, or is capable of being split, along the lamination or stratification planes, into tabular plates or flags.

The subvarieties are—(a.) *Arenaceous Flagstone,* and (b.) *Argillous,* according to whether they are sandy or clayey. Usually the layers are parallel to the true stratification-planes or the bedding, but not always, as in some cases the flags are due to oblique lamination.

NOTE.—In some rocks flaglike masses are due to cleavage, while in others to joint-planes. King (India) has proposed that the term *Flag* should be restricted to tabular masses due to bedding or stratification planes, while thin flat masses, caused by either cleavage or jointing, should be called *Slabs.*

c. *Slabstone,* or *Slabs.*—Cleaved or finely parallel-jointed rocks, which split into tabular plates or *slabs,* from one inch to three or four inches in thickness. Slabs are rarely as strong as flags.

Local Terms for Sandstones and Grits.

Catsbrains, sandstones traversed in every direction by little branching veins of *calcite. Rotch,* friable sandstone. *Rock* (quarrymen), any very hard

grit. *Freestone,* or *Free* (Ulster), a stone that cuts easily in every direction. *Hazel* (North of England), hard grit. *Binder* (Cork) and *Post* (North of England), beds of grit in shale, slate, or clay. *Peldon* (South Staffordshire), *Calliard* or *Galliard,* and *Crowstone* (North of England), a hard, smooth, flinty grit. *Brownstone* (Munster), grit and sandstone. *Red free* (Ulster), New red sandstone. *Granât* (Munster), coarse quartzose grit. *Brass-binder* (Cork), a thin pyritous grit. *Brass-balls* (Munster), *Stone-mine* (Leinster), nodules of pyritous grit. *Catsheads* (Leinster), nodules of hard grits in shale. *Cornstone,* containing calcareous concretions.

B. Argillous Rocks [Lat. *argilla,* clay], consisting for the most part of more or less argil, or clay. Other minerals and substances, however, often occur in the mass.

a. Clay, Loam, Mud, and Silt.—"Perfectly pure *clay* is a hydrated silicate of alumina, and when pure very plastic. *Loam* is a soft and friable mixture of clay and sand, enough of the latter being present for the mass to be permeable by water, and to have no plasticity."—*Jukes.* *Mud* and *silt* are more or less dry or moist mixtures of clay, loam, and sand; usually with decayed vegetable and animal matter.

The *subvarieties* of clay are very remarkable, and will require special descriptions. *Marl,* or *calcareous clay,* properly speaking, should be classed as a *subvariety* of clay. It seems preferable, however, to place it among the varieties of the argillous rocks, on account of its importance.

a. *Kaolin*, or *Porcelain-clay* (*see* Kaolin among the Ingenite Rocks); (b.) *Potter's*, or *Pipe-clay*, and (c.) *Brick-clay*.

Pure, or nearly pure clay, free from iron, usually of a whitish or light bluish-grey colour, is called Potter's clay. It is very plastic.

The best quality of *tiles* and *bricks* are made from Potter's clay; nevertheless, many impure clays are capable of being burned into bricks, and are commonly known by the name of *Brick-clay*. If clay is impure, owing to the presence of other silicates besides that of alumina, the bricks when burnt will be more or less ill-shaped and unsightly. In the neighbourhood of many bogs in Ireland is a deposit of dark sandy clay, locally called *Doab* (Connaught), used for making floors, or for plastering when mixed with a little lime.

d. *Fire-clay*. — Clay containing much silica or fine sand, nearly or quite free from iron; often blackish from containing carbonaceous matter, which, however, does not prevent it from burning into bricks or tiles which stand the fire.

Of Fire-clay Jukes writes: "It is probable that in good fire-clays, the silica and alumina exist in just that definite proportion which would form a true silicate of alumina."

Local Terms for Fire-clay.

Seat, Coal-seat, Coal-clay, Seat-clay, Under-clay, Buddagh, Soft-seat, Spavin.—In Munster the term *Seat* is often used to denote the nearest bed of clunch, grit, or sandstone under a coal; while the intervening fire-clay is called *Soft-seat*, &c. In

Leinster a highly carbonaceous, soft, muddy-looking fire-clay is called *Buddagh*, and for a similar rock the term *Spavin* is used in Yorkshire.

e. *Clunch.*—A tough more or less sandy indurated clay; characteristic of the Coal-measures and the Gault, but also found in other formations.

In Munster clunch is usually known as *Hard-seat* or *Seat-rock*, as it often occurs below a coal or fire-clay. These names, however, are not always restricted to it, for sometimes a grit or sandstone underlying a coal or fire-clay, may be so called. In Yorkshire and Lancashire a very hard siliceous variety is called *Ganister*.

f. *Clay-stone;* (g.) *Clay-rock* (Jukes).

Clay-stone is a compact and tolerably solid mass, chiefly consisting of clay. It may be laminated, but not slaty; its fracture earthy. *Clay-rock* is highly indurated, or solidified clay or clay-stone; it is not laminated like *shale*, nor cleaved like *slate*. It may pass into shale by merging into a laminated mass; or into slate, by becoming cleaved.

h. *Lateryte*, or *Laterite*, *Brick-stone* [Lat. *later*, a brick], a brick-coloured (reddish or brownish) arenaceous clayey rock, sometimes conglomeritic; soft before being exposed to atmospheric influences.

Lateryte is a *Tertiary rock* of India, which, while soft, is cut into large brick-shaped masses (hence the name), which on exposure to the air, harden. These are extensively used for building purposes. Some of the Lateryte from Kutch is evidently *tuffose*, or formed for the most part from the fine

débris of igneous rocks. A similar character belongs to rocks from other Indian localities, while other varieties seem not to contain any tuffose particles; usually it appears to be more or less associated with bedded or stratified igneous rocks. Lateryte may be very ferruginous, even so as to be classed as an *Earthy Limonite*. In Antrim, Ireland, associated with Igneous rocks of tertiary age, are rocks that seem to be identical with some of the Indian laterytes; while in Mayo, Ireland, there are somewhat similar rocks interbedded with Eurytes, of Upper Silurian age. Some varieties of Lateryte, both in Kutch and Antrim, appear to pass into a *Steatitic rock*, or even *Steatyte*.

i. *Fuller's Earth* (*see* Fuller's earth among the Ingenite rocks).

Other subvarieties of clay are—(j.) *Bituminous*, (k.) *Saliferous*, (l.) *Variegated*, (m.) *Hematitic*, (n.) *Ferruginous*, and (o.) *Book*, or *leaf clay*, deposited in thin leaf-like laminæ.

b. MARL, *Calcareous Clay*, an aggregate of clay, with more or less lime; earthy, compact, or fissile. Disintegrates when exposed to the atmosphere, and effervesces with acid.

Subvarieties in composition are—(a.) *Very calcareous*, the passage-rock into soft limestone; (b.) *Dolomitic*, (c.) *Very argillous*, (d.) *Arenaceous*, (e.) *Micaceous*, (f.) *Oil-slate*, or *Oelschiefer*, a bituminous dark-coloured subvariety; (g.) *Glauconitic*, of a green colour; and (h.) *Gypseous*, containing strings or thin laminæ of gypsum.

In structure there are—(i.) *Shell marl*, and (j.) *Mealy*, or *Friable marl*. The latter, when

typical, is due to lime in solution, being deposited by the evaporation of water. On the other hand, *Shell marl* is partly due to the decomposition of shells, and partly to an admixture of mealy marl. Others are—(k.) *Marl-stone,* a more or less indurated marl, without either lamination or cleavage; disintegrates when exposed to the atmosphere; (l.) *Tutenic,* or *Cone-in-cone marl,* that has a cone-in-cone structure; these concretions being called tuten in Germany; (m.) *Book,* or *Leaf marl,* a marl deposited in very thin laminæ; a cross section having the appearance of a closed book.

c. SHALE [Ger. *schalen,* to peel or shell off].—A compact, fissile, clayey rock; its fissile texture due solely to the rock having originally been deposited in laminæ or leaves. It is very variable in colour, and usually contains many impurities.

Subvarieties in composition are—(a.) *Calcareous,* (b.) *Arenaceous,* (c.) *Micaceous,* (d.) *Bituminous,* (e.) *Carbonaceous,* (f.) *Hematitic,* and (g.) *Cupriferous.* Structural varieties are (h.) *Flaggy,* (i.) *Conglomeritic,* (k.) *Nodular,* (l.) *Concretionary,* (m.) *Spheroidal,* (n.) *Lenticular,* (o.) *Mudstone* (Murchison), shales which on being exposed to the atmosphere, "rapidly decompose, and are converted into their primitive state of mud;" and (p.) *Tutenic* (cone-in-cone).

d. SLATE, *Sclate, Clay-slate* [originally spelt *sclate,* old French *esclat,* a splinter, a shingle; Celtic *Scorlt,* to split or cleave]. A shale or clay-rock in which a more or less perfect

slaty cleavage has been superinduced. The cleavage sometimes is much distorted.

Some slates (see *ante,* page 89) may be in part of metamorphic origin; most slates, however, are more nearly allied to the shales than to any other kind of rock. In all slaty or cleaved rocks there is a superinduced structure which gives the rocks a tendency to split into thin plates, whose direction is generally more or less oblique to the planes of the stratification; however, this may be perpendicular to, or even coincident with, these planes. Cleavage, as proved by Haughton and others, is due to the pressure, which has also produced the bending and folding of strata.

Slates may have been originally either shales or clay-rock, into which cleavage was introduced. If originally shale, there will be a lining or riban in the slate coinciding with the lines of deposition, while cleaved clay-rock without riban, is usually more homogeneous, and consequently generally makes the better and purer slate. The more argillaceous the rock, usually the more perfect the cleavage, while the slates have a submetallic ring. Good slate is called by the quarrymen *good metal.*

NOTE.—If cleavage in general is due to pressure, it should naturally be more prevalent among the older than the newer rocks; according to Agassiz, however, it may be sometimes due to induration, as that author mentions cleaved shales (*slates*), noted by him in Brazil, which he supposes to be part of the *Boulder-clay drift.* In them he records a perfect cleavage, which he suggests is due to the extreme tropical heat.

Subvarieties of slate are—(a.) *Roofing slate,* a pure or nearly pure slate, having smooth and perfect cleavage, allowing the rock to split into very thin plates, which at the same time are rigid, solid, and strong.

NOTE.—Some *so-called* slates, such as the *Stonefield slate* (which are sold for roofing purposes), are, correctly speaking, not slates, as such rocks split into plates not along the cleavage-planes but along the planes of lamination. Such miscalled slates are always coarse and unsightly, compared with true slates.

b. *Slabs,* or *Slab-slates.*—Pure or nearly pure slate, in which cleavage is only partially developed; consequently the rocks will not split into plates thin or light enough for roofing purposes; it however splits in parallel more or less thick plates, and can be manufactured into slabs.

c. *Pencil-slate, Pencil, Pinsill.*—Pure soft, but firm slate, which breaks easily into long spike-like prisms.

This fracture seems due to the cleavage, and two or three systems of close-lying joints, running in similar directions, and so placed as to divide up the rock into long, more or less regular narrow pieces. Lamination or foliation may take the place of one of the joint systems. These long narrow prisms are used as *pencils* for writing on slabs; whence the name.

d. *Novaculyte,* or *Novaculite* [Lat. *novacula,* a razor], *Whetstone, Whetslate, Hone, Oilstone.*—A highly siliceous clay-slate or shale, perfectly compact and homogeneous; usually only indistinctly cleaved; with a conchoidal or semiconchoidal fracture along the grain of the rock, and from uneven to hackly across it.

NOTE.—Many of the *Novaculytes* seem more allied to the Unmetamorphic than to the Metamorphic argillaceous rocks; nevertheless they often occur in the vicinity of outburst of Igneous rocks, thereby suggesting that the hardening and silicification is partly or wholly due to vulcanism.

Other subvarieties of slate are—(e.) *Calcareous*, (f.) *Carbonaceous* (these often afford an even roofing-slate, but are more or less soft and affected by nodules and seams (*Bulls'-eyes* and *Rucks*) of pyrite), (g.) *Arenaceous*, (h.) *Tuffose*, (i.) *Ribaned*, and (k.) *Conglomeritic*.

The last has, in a slaty matrix, fragments, often of quartz, rarely exceeding the size of a large pea or small marble, but usually about the size of shot. This rock is sometimes erroneously called Porphyry.

Local Names for Shale and Slate.

Rock-bind, Stone-bind, Fekes (Scotland), and *Blue-rock* (Leinster), arenaceous shales. *Bind, Killas* (Cornish) and *Slig* or *Sliggeen* (Irish), either shale or slate. *Bury* (Kilkenny) and *Flucan* (Cornish), soft shale or clay. *Metal*, compact flinty shale. *Plate*, flaggy shale-bed. *Shingle* and *Gravel*, names used in Ireland for shale or slate that breaks up into small angular pieces; usually they cannot be blasted, but must be worked by the pick, bar, or wedge.

C. Fault-rock.—Fault-rock is usually a mechanically formed rock, but in many instances it is also in part chemically formed. It may be conglomeritic, brecciated, arenaceous, argillous, shaly, or schistose (metamorphosed). Some of the metamorphosed fault-rocks are peculiar, especially the brecciated, calcareous, and dolomitic rocks.

Note.—Fault-rocks, properly speaking, are not subaqueous; nevertheless, it seems more appropriate to mention them here than elsewhere.

B. **Rocks for the most part chemically formed.**—Such rocks, when typical, are nearly solely due

to chemical action; they are more common in veins, nodules, and patches, than in beds or interstratified masses. Chemically-formed rocks are always insignificant, when compared with the associated mechanically-formed rocks, and often the former graduate into the latter.

A. HALYTE, ROCK-SALT [Gr. *hals*, salt; *lithos*, stone].—A crystalline, granular, translucent or transparent rock, consisting almost entirely of chloride of sodium; colourless, or of grey, yellow, reddish, occasionally bluish, or greenish colour; soluble in water; taste saline. Of Halyte, Cotta writes: "In Nature it almost always contains sulphate of lime, chloride of calcium, chloride of magnesium, and other salts; frequently admixtures of bitumen, clay, or boracite."

Varieties are—*a. Granular*, *b. Sparry*, and *c, Fibrous*, or with a wood-like aspect.

Halyte always merges into impure varieties, the impurities having a more or less mechanical origin.

B. GYPSUM [Gr. *ge*, earth; *epso*, I boil].—A hydrated sulphate of lime; usually crystalline, but sometimes compact or fibrous; soft; generally white or whitish.

a. Alabaster [after *Alabastron*, a town in Egypt].
b. Granular Gypsum, always almost white, somewhat translucent; granular and finely crystalline; sometimes it is fissile, each bed being composed of many layers of little crystals, slightly differing in colour and texture.
c. Compact gypsum, rare.
d. Fibrous, or having a wood-like structure.

e. Selenyte, Spathic or *Sparry gypsum,* transparent varieties.

f. Tripestone, "a variety both of texture and composition. It is formed of thin layers of pure white gypsum, alternating with grey argillaceous gypsum, the whole twisted or crumpled to resemble a ruff." — *Cotta.* Gypsum merges into impure, more or less mechanically formed varieties.

C. ANHYDRYTE, or ANHYDRITE.—"A granular or compact aggregate of anhydrous sulphate of lime; harder than gypsum; white, grey, or blue."—*Cotta.*

The varieties of anhydryte are very analogous to those of gypsum, the more marked being—*a. Granular, b. Compact,* and *c. Fibrous.*

D. DOLOMYTE, or DOLOMITE [after M. Dolomieu].—A granular crystalline aggregate of dolomite associated with some calcite; more or less saccharoid; does not effervesce, or only slightly with dilute acid. Dolomyte weathers into a ferruginous sand, *Dolomitic sand.*

NOTE.—Some dolomytes are of purely chemical origin, while most dolomytes are partly chemically and partly mechanically, or even perhaps organically, formed. Only the first belongs to this group (B), the others are described in group (C), page 120.

E. QUARTZ.—Pure or nearly pure silica.

Varieties of Quartz are—*a. Chert* [Celtic *cairt* or *chairt,* rough bark; as chert forms a rough bark or coat to the beds of limestone], *b. Flint, c. Menilyte,* or *Menilite.* Hard, compact, containing more or less carbonaceous matter; breaks with from a conchoidal to a semiconchoidal fracture; colour white, grey, yellowish, brown, black, and sometimes blue.

Chert, Flint, and *Menilyte* occur in layers of nodules, thin beds, and concretions; sometimes, however, as is especially the case with chert, they form massive strata. *Menilyte* is found in the Tertiary limestone. *Flint* is characteristic of some chalk, while chert is mostly found in the Carboniferous and older limestone, and in some shales. Jukes writes of these rocks, "Almost all large masses of limestone have their flints or siliceous concretions. Pure siliceous concretions occur even in the fresh-water limestones and gypsum beds of Montmartre."

d. Jasper and *e. Agate* (particoloured varieties). *f. Basanyte,* or *Basanite, Touchstone,* or *Lapis Lydius* (Pliny), a velvet-black cherty variety, used on account of its hardness and black colour for trying the purity of the precious metals.

F. LIMONITE ROCK.—A fissile, porous, compact or fibrous, earthy or arenaceous hydrated oxide of iron, bedded or in veins; reddish, yellowish, or blackish in colour.

Varieties are—*a. Limonitic Shale; b. Oolitic Brown Ore; c. Reniform Iron Ore; d. Pea-iron Ore; e. Bog-iron Ore:* the latter having sub-varieties, (a.) *Black Bog-iron Ore;* (b.) *Yellow Bog-iron Ore,* or *Yellow Ochre;* and (c.) *Sparry Bog-iron Ore.*

Limonite Rock sometimes occurs interstratified among rocks of Secondary age,* but other vari-

* In co. Clare, Ireland, it occurs in beds among Cambro-silurian rocks, while in Limerick and Queen's counties it has been found associated with black shales near the junction of the Carboniferous limestone and the lower shales of the Coal-measures. In Ulster it occurs interbedded with Whinstone of Tertiary age.

eties, such as *c*, *d*, and *e*, usually occur associated with surface accumulations, such as drift or peat. Cotta writes of *Oolitic Brown Ore*, that it "occurs in the form of layers in many formations." *Bog-iron Ore*, and its sub-varieties, are due to the decomposition of iron ores (often pyrite or marcasite), or minerals, or rocks containing a large percentage of iron. *Black Bog-iron Ore* in general is rich in manganese, while the *yellow* and *sparry* subvarieties are respectively argillaceous and siliceous.

G. Hematite Rock.—A granular or compact aggregate of hematite, with arenaceous or argillaceous matter; usually reddish in colour, but sometimes blackish or rich brown.

Varieties are—*a. Red-iron Mould*, or *Red Ochre*; *b. Reddle* or *Raddle*; *c. Sparry Red-iron stone*; *d. Specular Iron.*

Of these varieties, the principal are *a*, *b*, and *c*, while *d* seems to be rather rarely a rock-mass.

e. Topanhoacanga, or *Moorshead Rock.* — This Brazil variety is found among the surface deposits, and consists of fragments of specular iron, micaceous iron, and magnetite in a ferruginous matrix. In this rock there are various accessories; even, on rare occasions, grains of native gold.

H. Spherosideryte, or Spherosiderite, *Clay-iron Stone.* — A crystalline aggregate of siderite combined with argillaceous and carbonaceous matter. Impure varieties are arenaceous.

Spherosideryte, or *Clay-iron Stone*, occurs in thin beds, layers, and nodules, in beds of clay, clunch, and shale. It is typical of the coal-measures, but

is also found associated with other rocks. An important Coal-measure variety, very rich in carbonaceous matter, is said by Bristow to be called *Black-band*. Some beds of the latter are so rich in carbon, that they can be burned by themselves, and might be classed among the coals.

I. MINERALS OCCURRING AS ROCKS.— Some minerals occur in subordinate masses interstratified with the sedimentary rocks; these, however, are not of very frequent occurrence, minerals in mass more often being found in veins, nodules, or irregular accumulations.

a. Asphalte [Gr. *asphaltos*], *Bitumen, Mineral Pitch.*—Colour brownish, blackish, or black; lustre like that of black pitch, odour bituminous, melts at from 90° to 100°, and burns with a bright flame.

Of this rock Dana writes: "Asphaltum belongs to rocks of no particular age; the most abundant deposits are superficial."

b. Pyrite occurs in thin beds, layers, and as nodules.

c. Cinnabar.—"Occurs in beds in slate-rock and shale, and rarely in granite or porphyry." —*Dana.* This observer also states that this mineral occurs as rock-masses, both in unaltered and metamorphosed sedimentary rocks.

d. Boracite "occurs in beds of anhydryte, gypsum, and salt."—*Dana.*

e. Trona, "in North Africa, forming a rock which is even used for building purposes." —*Cotta.*

f. Aragonite, with its subvariety *Flosferri.* "The

most common repositories of aragonite are beds of gypsum, and beds of iron ore (where it occurs in coralloidal forms, and is denominated *Flosferri*), basalt, and igneous rocks."—*Dana.*

g. *Manganese Ores,* generally in the older rocks, but also in surface deposits.

h. *Rhodochrosite* occurs generally in veins, but at Glendree, Clare, Ireland, it forms part of the surface-deposits.

i. *Bole,* in subordinate masses, in limestone.

j. *Opal,* or *Vitryte,* in very subordinate masses.

k. *Fluorite,* and *l.* *Barite,* rarely found in beds or layers, often occur as gangue in mineral veins.

m. *Ankerite,* sometimes as an independent rock.

n. *Malachite,* usually in veins.

o. *Melanite,* in small accumulations.

p. *Galmey,* or *Calamine,* as aggregates in dolomyte.

q. *Zincite,* *r.* *Galenite,* *s.* *Stibnite,* and *t.* *Arsenopyrite,* rarely occur as subordinate layers, but more generally in veins.

u. *Sulphur,* in concretions and layers, principally in marl and limestone, also in the vicinity of volcanoes.

v. *Wavellite,* in subordinate beds or layers.

w. *Chalcopyrite,* usually in veins.

C. **Rocks partly mechanically, partly chemically, and partly organically formed.**—These rocks are always more or less crystalline, and usually occur as subordinate beds, interstratified with sedimentary rocks, but not always.

A. Laminated or Stratified Coal.—A more or less fissile crystalline aggregate of carbonaceous

matter; arenaceous or argillaceous to a greater or less degree.

Most coals do not belong to the Subaqueous rocks; some, however, have been formed mechanically from carbonaceous matter, that was first denuded, and afterwards deposited in the sea, or other waters.

NOTE.—At the present day the accumulation of mechanically-formed coal can be observed. Wherever *peat-bogs* or even hard *coal-beds* are exposed to denudation, more especially to marine abrasion, they are gradually carried away to be deposited in seas, lakes, &c., forming stratified more or less arenaceous or argillaceous carbonaceous beds, which eventually must be indurated, forming a hard coal. Some of these deposits in the vicinity of the Irish coast are of considerable thickness.

Varieties are—*a. Cannel Coal,* a compact, semi-fissile coal; breaks with a semiconchoidal smooth fracture, with little or no lustre; colour dull black or greyish black.

Cannel Coal is bituminous and often caking. Of it Dana writes: "On distillation it affords, after drying, 40 to 66 of volatile matter, and the material volatilized includes a large proportion of burning and lubricating oils. It graduates into oil-producing coaly shales, the more compact of which it much resembles."

NOTE.—Some varieties of anthracyte have erroneously been classed as Cannel coal, on account of their smooth, close texture.

Subvarieties are—(a.) *Parrot Coal,* (b.) *Horn Coal.*

A Scotch subvariety is called *Parrot Coal,* because it burns with a crackling noise; while a Welsh is named *Horn Coal,* as it emits, when burning, an odour like that of burnt horn. An earthy subvariety is called, in Yorkshire, *Clod.*

And (c.) *Torbanyte, Boghead Cannel, Boghead Mineral* (after *Torbane Hill,* Scotland).—A dark brown variety of cannel coal; yellowish streak, without lustre, and having a subconchoidal fracture.

Torbanyte yields over 60 per cent. of volatile matter, and is used for the production of burning and lubricating oils, paraffin, and illuminating gas.

b. Splint Coal, Splent Coal.—A hard, laminated, bituminous coal; not easily broken or kindled, though, when lighted, it affords a clear, lasting fire.

According to Page, the name "Splint" or "Splent," is derived from the coal splitting (or *splenting*) up "in large flaggy or board-like laminæ."

c. Culm, a fissile, flaggy, shaly, flaky, or scaly variety of non-bituminous coal or *Anthracyte.*

Culm sometimes occurs in independent beds, but more often it is found associated with *Anthracyte.* The flaky or scaly nature of some culm may possibly be due to the growth and decay of organic matter in layers, but in others undoubtedly it is due to carbonaceous matter having been deposited in water.

d. Bituminous Shale, and *e. Carbonaceous Shale.*—Respectively bituminous or non-bituminous shaly aggregates of coal, clay, sand, and such-like; more or less crystalline; colour black, or blackish-brown.

Both the bituminous and carbonaceous shales graduate on the one hand into argillaceous shale, and on the other into coal. The former merges

into *Cannel*, and the latter into *Culm*. The sub-varieties a and b are bituminous, while c, d, and e are non-bituminous. Some bituminous shales are impure coals; that is, they are capable of being used as fuel, while the poorer kind will not continue to burn in the fire, but become ash, the "slate" of the coal-merchant. Burning and lubricating oils, illuminating gas, &c., can be procured from many of the *Bituminous shales*. In general the *Carbonaceous shales* are not of much value; a few, however, when mixed with anthracyte, make a strong and lasting fire.

Local Terms for Bituminous Shale.

a. *Batt* and *Bass* (Staffordshire), (b.) *Dauks*.

Local Terms for Carbonaceous Shale.

c. *Kelve* (Leinster), (d.) *Pindy* (Cork), (e.) *Slaty Culm* (Limerick and Clare).

NOTE.—The other coals, such as *Peat*, *Lignyte*, and *Black Coal*, are classed and described among the SUBAERIAL ROCKS (page 122); they having accumulated on the surface of the earth, prior to having been buried and covered by more recent deposits.

B. LIMESTONE.—A more or less crystalline aggregate of calcite, in association with a greater or less quantity of carbonaceous, argillaceous, and arenaceous matter; compact, porous, fissile, amorphous, or oolitic; very variable in colour.

Some limestones are made up almost entirely, others only partially, of shells, fragments of shells, corals, madrepores, and such-like; others for the most part are due to the precipitation of lime held in solution by water; while some in a great measure are mechanically formed, preëxisting calcareous

rocks having been denuded away and the detritus deposited in water. Limestones in general, however. appear to be more or less due to a combination of two or more of these modes of formation.

Limestone may contain magnesia, silica, alumina, bitumen, ores of iron, &c., either as mechanical admixures or as chemical deposits, in conjunction with the carbonate of lime; and the presence of such minerals occasions many varieties in colour as well as composition. Of limestone Jukes writes: "Varieties of limestone occur in different localities, both geographical and geological, peculiar forms of it being often confined to particular geological formations over wide areas; so that it is much more frequently possible to say what geological formation a specimen was derived from, by the examination of its lithological characters, in the case of limestone, than in that of any other rock."

NOTE.—The colour of many, if not of most, limestones seems due, in a great measure, to the ores of iron chemically or mechanically contained therein. Dark blue or blackish limestones, when followed to a good depth, are nearly always found to be of a greenish colour. Red and variegated limestones in depth are generally grey or dove-colour, while all yellowish limestones, when in their normal state, have a greenish shade, no matter how pale.

a. Compact Limestone.—Homogeneous and fine-grained; fracture sometimes uneven, but generally conchoidal, either earthy or smooth; may be argillaceous, siliceous, magnesian, or ferruginous.

b. Crystalline Limestone.—An aggregate of crystals of calcite, fine or coarse, in association with argil, silica, and the like.

Typical *Crystalline limestone* belongs to the me-

tamorphic rock series; nevertheless, most sedimentary limestones are more or less crystalline, some being aggregates of large well-developed crystals. Jukes found the limestone forming the "great barrier coral reef," Australia, "to have a crystalline structure internally."

c. Marble [Lat. *marmor*].—Any limestone capable of being cut and of taking a fine polish.

Marbles may be *unicoloured*, such as pure black, white, grey, &c.; or they may be *particoloured*, deriving their colour from contained minerals or animal remains. Homogeneous rocks, both as to texture and hardness, cut more evenly and take finer polish than others, and make the better marbles.

The names by which marbles are known are very various; some are called after the localities in which they are found; others after their colour or the shells they contain, or any other peculiarity that may give a character to a rock.

d. Oolyte, or *Oolite* [Gr. *oon*, an egg, and *lithos*, a stone], *Roestone*.—Spheroidal concretionary structure, having the appearance of the egg or roe of a fish.

Subvarieties are—(a.) *Pisolyte*, or *Pisolite* [Lat. *pisum*, a pea], *Peastone*, which has a resemblance to an agglutination of peas; and (b.) *Dolomitic Oolyte*, there being minute spheroids of dolomite in a limy matrix.

Each concretion is formed of numerous concentric layers, being sometimes hollow at the centre, or it may inclose a minute particle of sand or other mineral substance.

NOTE.—Oolitic rocks are typical of one of the *Secondary geological groups*, which has been given the name of the *Oolitic formation*. This structure, however, occurs in other groups, but more especially in the Carboniferous limestone.

e. Chalk [Lat. *calx*, lime].—Usually a white or whitish fine-grained rock, but sometimes greyish, or even red; often earthy or pulverulent, but sometimes hard and compact.

Subvarieties are—(a.) *Indurated chalk*, called *White limestone* in Ulster. Jukes thus describes it: "Considerably harder and firmer than the friable rock which is commonly known as chalk." (b.) *Chalk-rock* (Whitaker), a siliceous variety; (c.) *Pisolitic chalk*, or *Maestricht*, which has a minutely spheroidal structure; (d.) *Glauconitic chalk*, greenish from containing glauconite; and (e.) *Ferruginous* or *Red chalk*, coloured red by oxide of iron.

f. Calc-sinter, or *Calcareous Tufa*, a loose and friable variety of calcite deposited from water charged with lime.

Subvarieties are—(a.) *Travertine*, (b.) *Stalactyte*, (c.) *Stalagmyte*, and (d.) *Rock-meal*. When compact, hard, and semi-crystalline, it is called *Travertine*; if deposited in long mammillated and pendent masses from the roof of a cave or fissure, *Stalactyte* [Gr. *stalactis*, that drops]; while the boss formed on the floor of the cave or fissure from the lime in the water which dropped, is named *Stalagma* [Gr. *stalagma*, a drop]. *Rock-meal* is a white and light calc-sinter that becomes powder on the slightest pressure.

g. Coral-reef Limestone.—Limestones in course of formation, consisting of corals, shells, and

calcareous sand or mud, often more or less crystalline.

h. Brecciated Limestone, Limestone Breccia, and *i. Limestone Conglomerate,* or *Puddingstone.*— A rock that has an appearance as if fragments of limestone had been dropped into a limestone matrix.

If the contained pieces are of different colours from the base, and the latter contrasts well, the result is often a handsome rock; the inliers are usually purer than the matrix, and weather more freely, giving the exposed surfaces of the rock a cellular tissue. If the inliers are round or roundish, the rock is called *Puddingstone Limestone.*

j. Rubbly Limestone.—A limestone made up of round or roundish irregular lumps and aggregates of lumps of various sizes, separated from one another by shaly partings, the latter being more or less calcareous.*

Limestones may also be called *Pebbly** or *Conglomeritic, Tuffose, Shaly, Slaty, Geodic, Cellular,* or *Porous,* if any of these structures extend over a considerable portion of the rock and give it a marked character.

k. Lithographyte, Lithographic Stone [Gr. *lithos,* a stone, and *grapho,* I write].—A very even-grained, compact, fine limestone, usually buff or drab-colour, employed in lithography.

Other varieties are,— *l. Siliceous Limestone, m. Cherty, n. Argillous, o. Arenaceous, p. Fer-*

* At Oughterard, Galway, Ireland, there are remarkable beds of *Pebbly limestone,* full of quartz fragments, generally of the size of large shot, and rarely larger than a pea.

ruginous, q. Bituminous, r. Stinkstone, or *Swinestone,* or *Fetid Limestone.*

If silica is diffused throughout the lime, the rock is *siliceous;* but if the silica is in separate nodules, concretions, or layers, the rock is *cherty;* while, if particles of sand are present, the rock is *arenaceous.* Cherty and argillaceous limestone, as also some kinds of siliceous limestone, when weathered, lose these calcareous portions, the residue being called *Rotten-stone.* Many bituminous limestones, when struck or rubbed, emit an odour of sulphuretted hydrogen gas, and these have been called by the different names of *Stink-stone, Swinestone,* and *Fetid Limestone.*

Important varieties are,— *s. Dolomitic,* and *t. Hydraulic Limestone,* or *Cement-stone.*

Hydraulic limestones are more or less dolomitic; they contain from 10 to 30 per cent. of silica, alumina, and magnesia. Some contain ores of iron, which are rather prejudicial than otherwise to their economic value.

Hydraulic limestone, when burnt, yields a lime that does not slake when water is added, but forms a mortar which will set under water. According to Dana, some hydraulic limestones should be classed as *Dolomytes.*

C. Dolomyte, *Dolomite* (after M. Dolomieu), *Magnesian Limestone.*—An aggregate of dolomite (bitter spar), combined with some calcite; usually also with more or less iron, some silica, alumina, &c.

The mineral Dolomite contains—carbonate of lime, 54·35; carbonate of magnesia, 45·65 (Dana).

The rock Dolomyte, according to Cotta, must contain 23 per cent. of carbonate of magnesia; while those calcareous rocks in which there is less than this amount should belong to the limestones.

Dolomyte is often geodic and vuggy, or containing numerous drusy cavities. The geodes and the lining of the cavities are usually crystalline (*Bitter spar*), and not uncommonly contain one or more isolated crystal or crystals of quartz (*Rock crystal*).

NOTE. — Dolomyte belongs to both the Ingenite and the Derivate orders of rocks; as some are due to metamorphism, while others were formed by the contemporaneous deposition of the carbonates of lime and magnesia, forming a Dolomyte or Magnesian limestone.

Dolomyte varies in texture. It may be, *a. Granular, b. Oolitic, c. Compact, d. Porous, e. Cellular, f. Concretionary, g. Brecciated,* or *h. Rubbly*. It also varies in composition, and may be, *i. Ferruginous, j. Argillous,* or earthy; *k. Arenaceous,* or sandy; *l. Siliceous, m. Cherty,* and *n. Tuffose;* they being analogous to the previously described varieties of limestone. It weathers into *o. Dolomitic sand.*

NOTE.—Cotta appears to be of opinion that *Dolomyte* is never oolitic. This however seems erroneous, as among the Carboniferous limestone in the cos. Limerick, Mayo, &c., Ireland, subordinate beds of *Oolitic dolomyte* occur. In Limerick minute spheroids of dolomite are disseminated in a calcitic matrix; while in Mayo the spheroids, as well as the base, are dolomitic or dolomyte.

Class II.—SUBAËRIAL ROCKS.

[Lat. *sub*, under; *aer*, lower air].—Rocks that were formed on the surface of the earth. Most of these, however, subsequently were covered by, or buried under, newer-formed strata, which may be either subaqueous, subaërial, or igneous.

D. **Mechanically, chemically, and organically-formed Rocks.** — Subaërial rocks are due to mechanical, chemical, or organic action, or two or more of these combined. The major part, however, including the principal rocks of the group, are more or less due to the growth and decay of organic matter, united with chemical action.

A. Coal.—This geologically includes and signifies all rocks, recent or otherwise, that can be ignited and kept burning without the addition of any other substance.

Note.—The burning properties of some *coals* can be improved by the addition of other substances, as of water to anthracyte; nevertheless, all rocks that are classed as coal should be capable of burning by themselves.

a. Peat, *Turf, Bog* [Celtic ? *peait* or *puit*, a soft miry substance].—An aggregate of organic matter more or less solidified, or indurated and mineralized; colour whitish-brown, yellowish-brown, blackish or yellowish white.

Subvarieties are—(a.) *White Turf*, (b.) *Brown Turf*, (c.) *Black*, or *Stone Turf*, (d.) *Gas* or *Candle Turf*.

Peat, or Bog, varies in appearance and texture, according to the position in which it is situated,

and the rate at which the accumulation was made. On low, flat land it grows much more rapidly than on hills or hill-slopes; consequently on the low land the peat is quite different from that on the hills, and in Ireland they are classed as *Low-bog*, or *Bawn*,* and *Mountain-bog*.

The Low-bog gives (a.) *White Turf*, (b.) *Brown Turf*, and (c.) *Black*, or *Stone Turf*; while the Mountain-bog only gives (b.) *Brown*, and (c.) *Black Turf*. On both there is an unprofitable surface or "clearing" (more or less living organic matter), which varies in thickness; on the former ranging from three to six feet in depth, while on the latter it rarely exceeds twelve inches in thickness.

Peat may be *fissile*, but more generally it is *felt-like*, the vegetable remains being interwoven, and forming a tough mass. The fissile texture of subaërial peat is due to vegetable growth;† each annual growth forming a separate layer. This is more common in some bogs than in others.

White turf is a nearly pure, if not an entirely pure, organic substance, and when burnt has little or no ash. *Brown turf* is always more or less

* *Bawn* (Anglicè *white*), so called from the white appearance the dead moss, grass, &c., have during the major part of the year, compared with the colour of the grass land and tillage in the vicinity.

† There are fissile peats in which the texture is caused by lamination, peat masses being denuded and subsequently deposited. Such peats, however, are not Subaërial, but are Subaqueous Rocks, and they are often interstratified, or mixed with clay, sand, or the like. Extreme heat or frost will break up peat, and leave it ready to be denuded and carried away by wind, or "rain and rivers," to be deposited in hollows, lakes, and such other reservoirs.

mineralized; while *Black*, or *Stone turf*, is a chemico-organic rock, often containing such minerals as pyrite, marcasite, and the like; when burnt, it leaves a considerable residue or ash; sometimes it is semi-crystalline, and often it is scarcely distinguishable from *Lignyte*.

NOTE.—The residue or ash of peat attains its maximum in the deepest portions of the bog; thus *Stone turf* will have more ash than the overlying *Brown turf*, and the latter than the *White turf*; while the subordinate parts of each have respectively more ash than the portions above them. The plants growing on the surface collect their inorganic food from the atmosphere, and after their decay, the mineral substances are being continually carried downwards by the water that percolates through the mass, the lower portions thereby becoming the most impregnated: some impurities also come up in water from springs.

Gas peat, or *Candle turf*, is not very common. It was found in a mountain bog on the island of Valencia, Ireland; was of a dirty yellowish-white colour; had the consistency of soap; when dried was very inflammable, and burned with a clear, bright, steady flame.

Peat accumulations are usually surface rocks, that is, rocks still growing at the surface, and being added to at the present day; it has, however, been found under drift and other surface deposits. *Æolian drift* may be blown over it; on a sunken coast-line it often is found under *Marine drift*; while in some places it has been found under *Boulder-clay drift*.

NOTE. — Cotta mentions peat in Germany "covered by diluvial loam." Oldham records peat "under a considerable depth of drift," near Nenagh, co. Tipperary, Ireland. Other Irish localities are the Boleyneendorrish valley, near Gort, co. Galway, under 25 feet of boulder-clay drift; and Newtown, Queen's co., under a thickness of 96 feet. The latter is three

feet thick, compact, solid, semi-crystalline, very bituminous, and blazing like a candle when lighted. It might almost be classed as *lignyte*.

b. Lignyte, or *Lignite, Brown Coal* [Lat. *lignum*, wood]. — Fissile or compact; woody or earthy; usually brown or black; streak brown; very inflammable, burning with much smoke and smell. A non-caking coal.

a. *Woody Lignyte*, (b.) *Compact Lignyte*.

Fremy has divided lignyte into two kinds; 1st, Lignyte that still displays woody structure, and 2nd, Lignyte exhibiting the aspect and compactness of soft coal.

c. *Jet* [*Jayet, Gagates*, after Gagas, a place in Lydia, Asia Minor].—"A black variety of brown coal, compact in texture, and taking a good polish."—*Dana*.

NOTE.—Jukes considers jet as a subvariety of cannel coal, while Page supposes it "is rather a species of amber than coal."

c. Black Coal, Steinkohle, Common Coal, Pit Coal. —A black, brownish-black, or greyish-black, compact or semi-compact mass, occasionally iridescent; lustre dull to brilliant, and either earthy, resinous, or submetallic; opaque; fracture conchoidal to uneven.

Subvarieties are—(a.) *Caking Coal*, (b.) *Non-caking Coal*, (c.) *Cherry* or *soft Coal*.

Mineral coal, according to Dana, should be "compact, massive, without crystalline structure or cleavage; sometimes breaking with a degree of regularity, but from a jointed rather than a cleavage

structure." Black coal may be a caking or a non-caking coal; the latter is sometimes called *Cherry* or *soft coal*. *Caking coal* softens and becomes pasty or semi-viscid in the fire, also it is inclined to form clinkers or to become welded together. *Cherry* or *soft coal* burns freely without softening, or any appearance of incipient fusion.

d. *Anthracyte*, or *Anthracite*, *Stone Coal* [Gr. *anthrax*, carbon].—Non-bituminous coal; lustre bright, often submetallic, and frequently iridescent; conchoidal, sharp-edged, shining fracture, or breaking readily into small cubical lumps.

Anthracyte appears not to be a normal rock, but to be an altered bituminous coal, from which the bituminous qualities have been extracted or expelled; sometimes it is an associate of Metamorphic rocks, but it also is found interstratified and associated with unaltered rock.

NOTE. — In Munster, Leinster, and Connaught, Ireland, anthracyte is interstratified with fossiliferous grits, shales, clunch, and fire-clay, the ordinary associates of bituminous coal, and these strata are not altered, except perhaps that they are more siliceous and harder than the ordinary coal-measure rocks in other countries. In places they are also cleaved.

A rock allied to Anthracyte is *Native coke*. It is undoubtedly an altered rock, due to the irruption of igneous rocks into beds of coal. Native coke is harder and more solid than artificial coke.

B. SURFACE DEPOSITS AND ACCUMULATIONS.—These may be peaty, clayey, sandy, gravelly, shingly, or a combination of two or more.

a. *Boulder-clay Drift*, a clayey or sandy-clayey matrix, sometimes calcareous, inclosing

more or less rounded, polished, grooved, scratched and etched blocks and fragments of one or more kinds of rocks.

Subvarieties are—(a.) *Calcareous* or *Corn-gravel,* (b.) *Argillous,* or *Till,* and (c.) *Arenaceous.*

Boulder-clay drift in general partakes more or less of the nature of the subjacent rocks, with a greater or less admixture of blocks and fragments of foreign derivation. The calcareous variety in Munster is called *Corn-gravel,* being used as a manure for corn-land, while the red argillous variety in Ulster is known as *Till.*

b. Moraine Drift, Boulder Drift, an accumulation having a more or less sandy, clayey, or gravelly matrix, containing angular or subangular, rarely rounded blocks and fragments of the adjacent rocks, foreign materials being in subordinate quantities.

Subvarieties are—(a.) *Calcareous,* (b.) *Argillous,* (c.) *Arenaceous,* (d.) *Rocky.*

Moraine drift when in low valleys often graduates into shingle, gravel, and sand, while on hill-slopes it may pass into *Rocky-moraine drift,* full of large angular blocks, often tons in weight.

c. Sand, gravel, and shingle, usually more or less stratified; sometimes containing thin beds or layers of clay; at times the materials are heaped confusedly together.

Subvarieties are—(a.) *Esker* [Celtic, ridge], *Kaim* [Celtic, *Kam,* winding], A°s or *Os Drift* (Scandinavian), (b.) *Post-drift Gravel.*

NOTE.—*Boulder-clay* and *Moraine drifts* are due to glacial or ice action, and therefore may be considered subaërial accumulations, even although some of the first may have been deposited in the sea or a lake. *Esker drift* seems to be either of the previously mentioned drifts, well washed, seemingly by marine or tidal currents. Some writers, while describing Asar and Kaims, evidently have included with them the "drumlins" or ridges of boulder-clay drift, which are quite distinct. The subvarieties (a and b), though not Subaërial Rocks, are yet described here, on account of their connection with the other *Surface deposits and accumulations*. (a) is probably of marine origin, while (b) may be marine, lacustrine, or fluviatile.

c. *Beaches.* — Sand, gravel, or shingle; often shelly.

Beaches usually occur in more or less level terraces, on account of their marking the margins of present or ancient seas or lakes.

d. *Æolian Drift* or *Sand, Quartzose* or *Rabbit Sand;* (e.) *Shell* or *Calcareous Sand.*—Fine incoherent sand: the first subvariety, when normal, is entirely composed of siliceous particles. In the neighbourhood of the sea it is more or less mixed with shells, corals, and such-like, or may graduate into *shell sand,* a calcareous accumulation of the débris of corals, shells, madrepores, and the like, sometimes containing as much as ninety per cent. of limy matter.

All these sands are also called *Blowing sands,* and are of various thicknesses up to hundreds of feet. Both Æolian drift and Shell sand may have been originally subaqueous, but their present arrangement, form, and character, are due to subaërial action. Some collections of Æolian drift, such as that of the Sahara, in Africa, seem to have been originally produced by marine action, as they occupy lately-

raised sea-basins. Other accumulations may be caused by meteoric abrasion; frost, heat, and chemical action disintegrating arenaceous rocks. But large quantities of it would appear to be glacier-formed, being due to the grinding of ice-bound rocks one against another, or the bottom and sides of valleys, forming sand or silt, that subsequently was carried down by a glacial river and deposited either in a lake or sea, at or near the mouth of a river. Such sands, when afterwards raised to form dry land, if in sheltered situations, would in time be clothed with vegetable mould; but if in exposed situations, they would be wafted hither and thither by every gust of wind, forming the ridges and hillocks known as *Sand-dunes* (Celtic, *doon*, hill).

At or near the mouth of most of the valleys in Ireland, which in prehistoric times were occupied by ice-streams, whether inland or on the seaboard, these accumulations of sand are found. In the plain of Limerick, at Killonan, opposite the mouth of the valley called Glencoloo, these sands have been proved to be over 200 feet in thickness.

f. *Bergmehl, Mountain-meal.* — An exceedingly fine earth, covering extensive tracts of country in Sweden, composed of microscopic siliceous shells, said by T. Rymer Jones to be due to a lake deposition.

d. Guano.—Accumulations of animal excrement and remains; more or less compact; sometimes semi-crystalline; very fetid; yellow, brown, or blackish-brown in colour.

e. Soil, Vegetable Mould, earthy, sandy, or peaty. —Due to the combination of meteoric action with vegetable growth and decay, along with the work of certain animals.

Any portion of the surface of the ground, if deprived of its vegetable soil, unless subject to extremes of heat or cold, or some such obstructive action, will in time regain its coating of soil. At the first, meteoric action disintegrates and ameliorates the surface, to prepare it for the growth and decay of vegetables; after which, as pointed out by Darwin and others, the operations of earthworms, ants, and such-like, accelerate the formation of soil.

Local Names for some Wine-growing Soils.

Albarizo (Sicily), a yellowish-whitish chalk-soil, consisting of lime, argil, and oxide of iron; an absorbent, spongy substance, loose, always fresh and open, not caking. *Barro* (Sicily), sand mixed with a clayey earth and gravel. *Arena* (Sicily), sand on which the vine thrives well and produces abundantly, but the grapes make a thin wine. *Bugeo* (Sicily), a blackish aggregate of clay, vegetable earth, and gravel. *Pedra Molla* (Madeira), soft rock-*débris*, which never becomes a fine mould, but is generally in a crumbly state, like small coal; in this surface-deposit the vines are planted.

NOTE.—All rocks, whether tenacious, like granite, grit, limestone, and the like, or fragile, like drift and the other surface accumulations, weather more or less freely when exposed to the atmosphere. If circumstances allowed such weathered portions to remain, a soil of a greater or less thickness would gradually form. In many localities, however, the detritus, as fast as it is formed, is carried away either by wind or rain and rivers, while in most other places more or less is removed prior to a protecting envelope being formed by the growth and decay of vegetation; and even after the envelope is complete, some of the earth, continually being brought to the surface by earthworms and the like, will be removed by wind and water.

f. Meteoric Drift, Clay, Sand, Gravel, and *Shingle, Meteorites.*

Under peculiar circumstances, in some localities, surface rocks that can scarcely be classed with soil, are formed by meteoric abrasion ; shaly slates, some limestones, and certain ingenite rocks weather into clays ; arenaceous and some ingenite rocks will produce sands, while certain limestones, conglomerates, breccias, and the like, weather into a coarse shingle or gravel. Meteorites in a few places, as in Greenland, form surface deposits.

NOTE.—In Brazil, Agassiz and others have noted the vast thickness of meteoric drift formed *in situ* by extreme heat ; while in Ireland, in many places on the extensive crags or flats of carboniferous limestone, a coarse shingle, more or less angular, is formed by the weathering of the rock.

g. *Ice* may be compact, granular, fibrous, or laminated.

Firn, or *Névé*, is the accumulation above the "snow-line," which becomes consolidated into granular ice. *Glacier ice* is indistinctly granular, with its lamination more or less contorted or even effaced. Ice that forms in crevasses is compact, while *Cave ice* may have interstratified beds of sand in it.

ALPHABETICAL INDEX to Local, Duplicate, and other Rock names, that do not appear in the Classified List, Part I.; the Local names being printed in Italics. In the second column are the names of the Rocks, under which the others will be found in Parts II. and III.

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